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STOCKAGE POLICY ANALYSIS. ANNEX A. COMPONENT DOCUMENTATION OF D--ETC(U)
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(6) STOCKAGE POLICY ANALYSIS

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ANNEX A

COMPONENT DOCUMENTATION

OF

DoD INSTRUCTION 4140.39

VSL/EOQ POLICY IMPLEMENTATION

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PART 3

AUGUST 31, 1980

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STOCKAGE POLICY ANALYSIS

ANNEX A

COMPONENT DOCUMENTATION

OF

DoD INSTRUCTION 4140.39

VSL/EOQ POLICY IMPLEMENTATION

PART 3

AUGUST 31, 1980

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1.0 VSL/EOQ ISSUE PAPERS

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT: Budget Formulation and Budget Execution Performance Goals

DOD POLICY: Neither ASD(MRA&L) nor ASD(COMPT) directives address specific goals for variable safety levels and order quantities to be used in budget formulation (i.e., stratification). DODI 4140.39 does set forth generally worded policy regarding budget execution goals: "...shortage parameter used in computation of the budget will be a function of the performance goals established by the Office of the Secretary of Defense while the shortage parameter used in day-to-day operations may be a function of funding levels or other management decisions..."

COMPONENT POLICY: Lacking DOD policy concerning performance goals, the Components have established performance goals independently. For expense items the goals are:

DLA: A backorder goal per ICP which is approved by DLAHQ.

Army: 85% requisition fill rate per ICP.

Navy: An overall requisition fill rate of 85% per ICP; higher fill rate goals on selected weapon systems (e.g., 95% for FBM weapon system support).

USAF: 55 days of safety level per ICP.

DISCUSSION: In order to establish a common base for the implementation of inventory control policies, ASD(MRA&L) promulgated DODI 4140.39. Throughout budget reviews, various audits and studies such as this DOD Stockage Policy Analysis study, comparisons are made of the Components' inventory models and systems. As has been seen during this study, there are differences among the Components' models. Furthermore, as seen above, there are significant differences among the performance measures of the Components (i.e., backorders, requisition fill rate, days of safety level). If valid comparisons are to be made, particularly during budget reviews, a common performance measure should be established and goals consistent with that measure should be established. It is to be noted that during recent budget reviews the performance measure of requisition fill rate has been almost universally recognized and accepted by the reviewers (i.e., COMPT, MRA&L, OMB) as evidenced by the safety level issue with Navy and the budget reduction for "too high requisition fill rate" with DLA. Therefore, any policy statement in this area promulgated by ASD(MRA&L)

must be recognized and accepted by ASD(COMPT) and OMB.

RECOMMENDATION: It is recommended that the resolution of this issue by ASD(MRA&L) be accomplished as follows.

a. Promulgation of a policy statement of which ICP response time is the recognized and monitored performance measure.

b. Convening a study group to analyze data from Components in order to recommend goals for performance.

c. Promulgation of goals.

VSL/EOQ SUB GROUP TASK 1 ISSUE

SUBJECT: DoD Instruction 4140.39 Constraints on Maximum Safety Level

DOD POLICY: DoD policy as stated in DoD Instruction 4140.39 requires that safety level (SL) be less than the smaller of expected procurement leadtime demand or three standard deviations of leadtime demand.

COMPONENT POLICY: All Components, except Navy, follow DoD policy virtually as stated in DoD Instruction 4140.39. The Navy does not constrain the safety level to be less than the expected procurement leadtime but currently has an effort underway to include this constraint.

DISCUSSION: The purpose of this discussion is to show that relaxing the maximum constraint on SL can improve the effectiveness of SL investment.

Let

LTD = Procurement Leadtime Demand
E(LTD) = Expected or forecasted LTD
σ(LTD) = Standard Deviation of LTD

Whenever E(LTD) < 3σ(LTD) the limit on maximum SL is E (LTD). The occurrence of this condition appears to vary among Components and depends on the types of items managed and the methodology for estimating σ(LTD). In particular, the use of leadtime variability in conjunction with demand variability when estimating σ(LTD) makes E(LTD)<3σ(LTD) more likely. Even without leadtime variability, however, Army items experience this condition virtually always. Some limited samples indicate it occurs often with Air Force items, and with some of the DLA centers.

It is easy to understand why 3σ(LTD) was included in the SL constraint. Basically, DoD Instruction 4140.39 requires the Components to compute SL's in a particular manner using a theoretical leadtime demand distribution with empirically estimated mean and variance. Since the accuracy of the distribution is most questionable in the tails, it is prudent to place a limit on SL which depends on σ(LTD). However, no logical reason for limiting SL by E(LTD) has been uncovered. Consequently, it is reasonable to ask what would happen if E (LTD) were removed from the maximum SL limit, i.e., SLmax= 3σ (LTD).

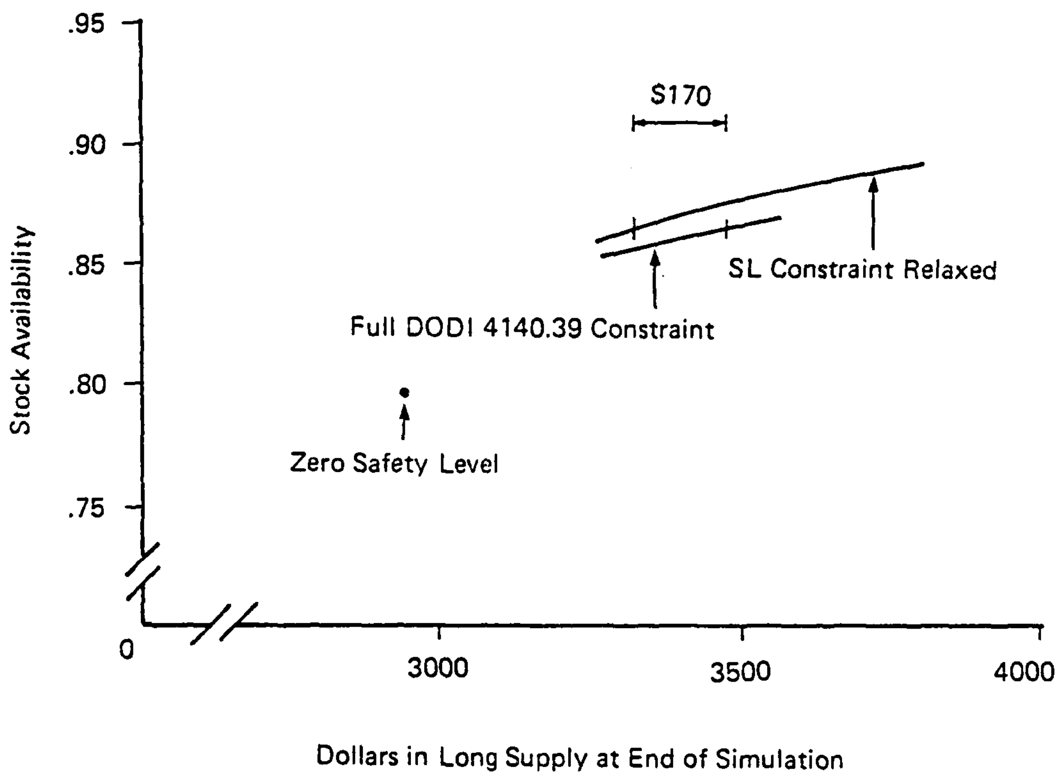
There are two bodies of information on relaxing the SL limit in this way. One was produced by the Air Force from simulation analyses done during development and subsequent implementation of DoD Instruction 4140.39. While these results have not been resurrected here, they indicated that substantial improvements were possible by relaxing the SL constraint. The other body of information was produced recently by the Army when

investigating ways to improve stock availability. Theoretical projections had shown that dramatic improvements could be had by relaxing the constraint, and these were substantiated with simulation analyses using actual demand history. The simulation results are shown in the two attached graphs. (Appendices A and B).

The first graph (Appendix A) shows Long Supply Dollars (dollar value of assets more than 2 years above the RO) vs Stock Availability. The second graph (Appendix B) shows Safety Level Dollars vs Stock Availability, for the full and relaxed constraint cases. The improvement in Stock Availability with the relaxed constraint is significant. It is important here to keep in mind that while the absolute difference in Stock Availability may look unimpressive, the improvement is gained in an area of high availability where improvements do not come cheaply. For example, in order to get 86.5% availability under the full constraint requires spending $120 more per item on SL than under the relaxed constraint. This is equivalent to a 37.5% increase in SL investment.

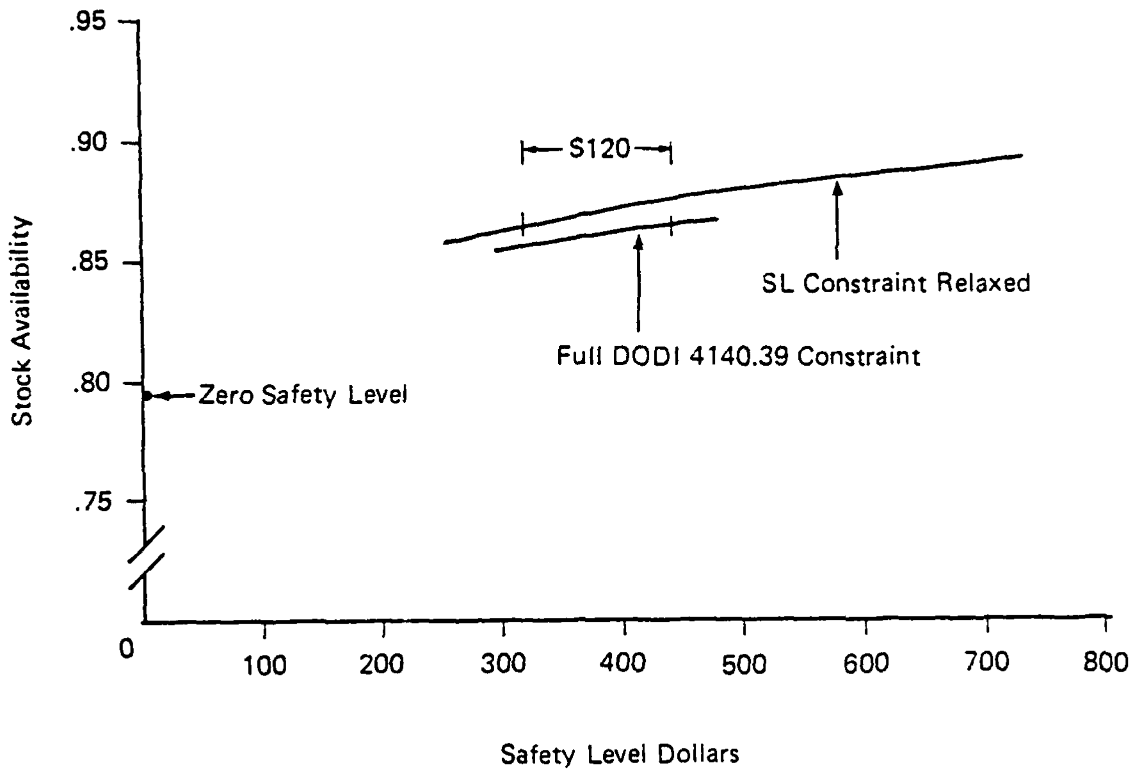
RECOMMENDATION: It is recommended that DoD policy on maximum SL be changed so that the only limit is 3σ(LTD). This would not require those Components who wish to retain the current limit to change. It would allow those Components who wish to change to do so.

Long Supply Dollars vs Stock Availabliity (units)



Attatchment 1
Simulation Results

Safety Level Dollars vs Stock Availabliity (units)



Attatchment 2
Simulation Results

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT: Constraints on the Order Quantity (Procurement Cycle) for Consumable Items

DOD POLICY: DODI 4140.39: "...Any set of decision rules...will be sensitive to extremes of cost and demand. For this reason, a procurement cycle of three months demand and a maximum procurement cycle of three years demand will normally be used. Deviations from these bounds are permitted where particular commodity characteristics, or procurement/industry practices such as quantity discounts or economics dictate otherwise;..."

COMPONENT POLICY:

DLA: Conforms with DODI 4140.39 constraints of 3 months and 3 years demand on procurement cycles.

Navy: Conforms with DODI 4140.39 constraints of 3 months and 3 years demand on procurement cycles. Selected categories of items approved by OASD during budget reviews have a minimum constraint of 6 months demand.

Army: Conforms with DODI 4140.39 constraints of 3 months and 3 years demand on procurement cycles. Selected categories of items approved by OASD during budget reviews have a minimum constraint of 6 months demand.

USAF: Conforms with DODI 4140.39 maximum constraint of 3 years demand, but utilizes a minimum constraint of 6 months demand on procurement cycles.

DISCUSSION: For at least a certain group of items, all Components are utilizing or are considering the prospect of utilizing a minimum constraint on procurement cycles in excess of the 3 months demand specified in DODI 4140.39. Those actions have been taken to limit the number of procurement actions initiated because of real world limitations on purchase and/or wholesale stock point receipt processing workload. In recent years, personnel reductions within the Department of Defense have led the Components to cut back resources devoted to procurement contracting and receipt processing.

To meet the resource limitation constraints, the Components have the option of limiting the number of purchase actions by taking one or more of the following actions:

a. Raising the minimum constraint on procurement cycles applied to all items in inventory or to selected groups of items.

b. Raising the cost to order value applied to all items in inventory or to selected groups of items. Note that since the Components utilize the Wilson EOQ formula (or some version based on the Wilson EOQ formula) as the starting point for computing procurement cycles, it is difficult to achieve the desired impact on the number of procurement actions initiated solely by raising the cost to order while maintaining the current DODI 4140.39 contraints.

c. Increasing the range of stocked items when demands for nonstocked items occur. When a demand for a nonstocked item occurs, buy a quantity to meet the demand and to place a minimum quantity on hand to meet any future demands. Note that this concept is contrary to the concept of minimizing investment in insurance and numeric stockage objective (NSO) items to minimize obsolescence and/or presumes the costs utilized in the economic range rule are not valid.

Needless to say, the most direct and easily determined means of controlling the number of procurement actions initiated is through the first option discussed above. And that is the route the Components have elected to utilize.

The underlying problem is that the range and depth rules do not explicitly address real world limitations on the number of procurement actions which can be effectively handled by the ICPs and/or the stock points. Furthermore, the rules governing operations of the DOD supply system do not allow for the most efficient operations since there can be no trade-offs between resource costs (O&M) and material costs (stock fund/appropriated purchases). The question is: Do personnel and ADP resources dictate inventory management policy or does inventory management policy dictate personnel and ADP resource requirements?

RECOMMENDATION: There should be a long range effort to determine the most cost-beneficial alternative of meeting real world resource constraints regarding the volume of procurement actions. The study should consider such alternatives as: buying shelf stock for nonstocked items when demand occurs, raising the minimum orders quantity constraint from three months of demand specified in DODI 4140.39 to some other value, changing the cost to order for items, and limiting the order quantity to no smaller than the administrative leadtime requirement.

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT:	Demand Forecasting	
DOD POLICY:	None	
COMPONENT POLICY:	DLA:	Utilizes double exponential smoothing.
	Army:	Utilizes arithmetical averaging methods.
	Navy:	Utilizes exponential smoothing methods for non-program related items and uses arithmetical averaging methods for program related items.
	USAF:	Utilizes arithmetical averaging methods.

DISCUSSION: The Components compute means (averages) and variances (i.e. mean absolute deviations, standard deviations) of demand in different manners. Each can produce studies and other rationale for their procedures. To change the procedures will require significant ADP changes and perhaps different data collection systems for some Components.

RECOMMENDATION: To standardize the demand forecasting procedures of the Components, a long range study should be undertaken to resolve the underlying issues (e.g. formula, time bases, frequency of forecasting, types of demand, etc.).

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT: Frequency of Procurement Reviews

DOD POLICY: None.

COMPONENT: Army: The Army system accounts for the period of time between procurement reviews by adding ½ the interval to the administrative leadtime portion of the model. Since the interval between procurement reviews is 30 days, Army uses a 15 day additive to the administrative leadtime.

USAF: The Air Force system accounts for the period of time between procurement reviews for consumable items with value-of-annual-demand < \$500 by adding the full interval to the administrative leadtime portion of the model. That period of time is monthly for such items. The frequency for other consumable items is 4 times per month and the interval is not incorporated in the model.

DLA: The DLA system makes a comparison of assets with requirements every time a transaction (e.g. demand, receipt, etc.) is processed against an item. This constitutes virtually a continual review.

Navy: The Navy system is designed to be run daily and therefore does not account for the period of time between procurement reviews. Procurement reviews are accomplished 4 times per week at SPCC and every 7-10 days at ASO.

DISCUSSION: The model of DODI 4140.39 assumes a continuous review environment; that is, the ICP is at all times aware of each item's wholesale requirements and its wholesale assets so that a procurement action will be generated precisely when assets fall to the reorder point. In actual practice, the DODI 4140.39 model does not operate in a continuous review environment. Rather procurement reviews (i.e. the comparison of assets to requirements) are made at periodic intervals (e.g. daily, weekly, monthly). During the interval between procurement reviews, the assets may fall below the reorder point that has been computed to provide a degree of protection against stock-out during the procurement leadtime--not the procurement leadtime plus the review interval. Thus, unless the procurement review interval is taken into account the expected degree of protection against stockout will not be achieved in practice.

RECOMMENDATION: It is recommended that OASD (MRA&L) issue the following policy statement as part of DODI 4140.39:

"It is recognized that the model of this directive is a continuous review model. If procurement reviews are not conducted at least daily, the procurement leadtime forecast utilized in computing the reorder point should incorporate the average interval of time occurring from assets actually reaching the reorder point to the subsequent procurement review operation. For simplicity, ½ of the average review interval may be used. This value is to be treated as part of the administrative lead time in the model."

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT: Forecasting Leadtime Variance and Leadtime Demand Variance

DOD POLICY: There is none that specifically addresses accounting for the variability of leadtime. DODI 4140.39 does define safety level to be the quantity of material...required to be on hand...in the event of minor interruption of normal replenishment or unpredictable fluctuation in demand.

COMPONENT POLICY:

DLA: Does not utilize the variance of leadtime in computing the variance of leadtime demand. The formula for the standard deviation of leadtime demand is

$$\sigma = 1.25\ (a + bT)\ MAD$$

Where:
T = number of forecast periods in procurement leadtime
MAD = mean absolute deviation of forecast demand
a,b = constants which are functions of the α factor used in forecasting

Army: Does not utilize the variance of leadtime in computing the variance of leadtime demand. The formula for the standard deviation of leadtime demand is

$$\sigma_{\text{Consumable}} = \frac{(PCER)\ (GAMMA)\ (LTD)}{\sqrt{(PROLT)\ (1.333)}}$$

Where:
PCER = % forecast error from a table for a 9 month demand forecast
GAMMA = factor to convert MAD to standard deviation
(LTD) (PCER) = estimate of MAD
$\sqrt{(PROLT)(1.333)}$ = a conversion of PCER to PROLT size

$$\sigma^2_{\text{Repairable}} = \left(\frac{RLT}{PLT}\right)\left(\sigma^2_{CONS}\right) + \left(1 - \frac{RLT}{PLT}\right)\left[(URR^2)\left(\sigma^2_{Cons}\right) + (URR)(1-URR)(PLT)(D)\right]$$

Where:
RLT = Repair leadtime average
PLT = Procurement leadtime average
URR = Unserviceable returns rate (%)
D = Recurring demand average
σ^2 = σ computed for a consumable squared

Navy: Computes and utilizes the variance of leadtime for repairable and for fast moving consumables in computing the variance of leadtime demand. The formulas for the variance of leadtime demand in those instances are:

$$\sigma^2_{\text{Consumable}} = (L)(1.25xMAD_D)^2+(D^2)(1.25xMAD_L)^2$$

$$\sigma^2_{\text{Repairable}} = (L-T)[(1.25xMAD_D)^2+(C^2)(1.25xMAD_S)^2$$
$$+ (S^2)(1.25xMAD_C)^2+(1.25xMAD_C)^2(1.25xMAD_S)^2]$$
$$+ (D-CxS)^2[(1.25xMAD_L)^2+(1.25xMAD_T)^2]$$
$$+ (T)(1.25xMAD_D)^2+(D^2)(1.25xMAD_T)^2$$

Where:
- L = Procurement leadtime average
- T = Repair cycle time average
- D = Recurring demand average
- C = Carcass returns average
- S = Repair survival rage average
- MAD_D = Mean absolute deviation of quarterly demand
- MAD_L = Mean absolute deviation of procurement leadtime
- MAD_S = Mean absolute deviation of repair survival rate
- MAD_C = Mean absolute deviation of quarterly carcass returns
- MAD_T = Mean absolute deviation of repair cycle time

USAF: Does not utilize the variance of leadtime in computing the variance of leadtime demand. The formula for the standard deviation of leadtime demand for a consumable is:

$$\sigma = (0.5945)(MAD)x(0.82375+0.42625\ LT)$$

Where:
- MAD = mean absolute deviation of quarterly demand
- LT = procurement leadtime average in months

The formula for the variance of leadtime demand for a repairable is:

$$\sigma^2 = 1.132477(LTD)^{.3407513}$$

Where: LTD = mean leadtime demand forecast

if the variance-to-mean ratio is less than or equal to 1, the variance-to-mean ratio is set to 1.00001.

DISCUSSION: From the definition of safety level provided in DODI 4140.39, it is clear that the safety level should cover normal fluctuations in both demand and leadtime. A key factor in the computation of safety level is the forecast of the variance (or standard deviation) of leadtime demand. Since the Components do not have ADP systems for collecting leadtime demands directly, forecasting routines must utilize a combination of demands and leadtimes and their respective variances in computing the forecast of leadtime demand variance.

RECOMMENDATIONS: OASD(MRA&L) issue a policy statement (as part of DODI 4140.39 or a Demand Forecasting Instruction) which simply states: the computation of leadtime demand variance used in safety level and reorder point computations should consider the variability of demand and the variability of procurement leadtime.

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT: Use of Nonrecurring Demand Observations in Forecasting Demand for Inventory Levels

DOD POLICY: DODI 4140.39: "...certain requirements computed separately, such as those in support of rework of higher assemblies, while coded nonrecurring, should be treated the same as recurring demands in the use of the model."

COMPONENT POLICY: DLA: Nonrecurring demand requisitions are coded "N", "P" and "O". "P" coded observations are considered to be preceded by planning data, while "O" coded are considered to be truly once-only demands. Items with a VAD ≦ $4500 utilize "N" coded observations the same as "R" coded observations in forecasting (i.e., the forecast base is the sum of "R" and "N" observations). Items with a VAD > $4500 utilize only a portion (%) of the "N" observations in the forecasing base. That portion (%) is determined by computing the ratio of 2 times the sum of the smallest two quarters "N" observations in the last four quarters divided by the sum of the last four quarters "N" observations.

Army: Nonrecurring demand requisitions for certain special programs (e.g., initial allowances, mobilization, FMS, basic issue, etc.) are not part of the demand forecasting base. Items with a VAD ≦ $5000 utilize other "N" coded observations the same as "R" coded observations (i.e., the sum of "R" and "N" observations form the forecasting base). Items with a VAD > $5000 utilize a portion of the "N" observations, where the portion (%) is an ICP set parameter.

Navy: The demand forecasting base for all items utilizes only "R" coded observations.

USAF: Items with a VAD ≦ $5000 utilize the sum of recurring ("R") and nonrecurring ("N") demand observations in the forecasting base. Items with a VAD > $5000 utilize only recurring demand observations in the forecasting base.

DISCUSSION: Currently the starting point for any discussion of the use of nonrecurring demand in forecasting must be the MILSTRIP demand Code entered on the requisition by the customer. Appendix B8, DOD 4140.17-M, contains the Demand Codes and their definitions. These codes must be understood before proceeding to their treatment by Inventory Control Points in requirements forecasting.

It is accepted by all Components that all demands which are correctly coded "R" should be used in forecasting. Codes "I" and "S" represent special cases which are not applicable to this task. Codes "N", "P" and "O", their use in requisitioning, and the extent to which they should be used in forecasting remain for discussion.

Code "P" is specifically designed for use by requisitioners when the requisition has been preceded by a MILSTRAP Special Program Requirement (SPR) which has been accepted with SPR Status Code PA. DOD 4140.22-M applies. Chapter 11 covers SPRs, and SPR Status Codes are defined in Appendix B12. Code "P" demands should be excluded from forecasting. Theoretically, each requisition bearing Demand Code "P" can be matched to an SPR, although in practice matching requisitions to SPRs is a difficult task. Both Navy and Air Force activities are major submitters of SPRs to DLA, and the Army plans to begin using them to forecast depot maintenance to DLA.

Code "O" is to be used when the requisitioner's demand is to be totally excluded from the forecasting base. Currently, this demand code is used in requisitions to DLA which have been preceded by SPRs for which Status Code PB has been received; in requisitions for prepositioned war reserve stocks; for initial lay-in requirements which do not reflect consumption; and in any other requisitioning situation which the requisitioner knows to be absolutely unique.

Codes "O" and "P" appear to be used with a reasonable degree of success by DLA; Components use codes "O" and "P" when requisitioning from DLA activities however, it does not appear that components use codes "O" and "P" to any large degree when requisitioning within their own Component.

While Codes "O" and "P" are fairly well defined in their intended use, Code N is used more or less at the option of the individual requisitioner. In DLA, it has been found that most demands considered nonrecurring by the requisitioner are, in fact, recurring at the supplier level. This is why all Code "N" demands are used in requirements forecasting for items with less than $4,500 in annual demand. For items with a greater demand value, where the risks of incurring long supply are greater, DLA "hedges" by using a proportion, between O and 100%, of the Code "N" demand.

The Navy models assume that all requisitions coded "N" (nonrecurring) by the customer have been preceded by planning information in sufficient time to allow the ICP to lay-in assets to meet the demand. In fact, not all

nonrecurring requisitions are preceded by timely planning data, and the inventory levels are not sufficient to meet actual demands for many items.

RECOMMENDATION: It is recommended that the following policy statement be issued by ASD(MRA&L) pending promulgation of a demand forecasting instruction:

> "The forecasting of demand, to be used in computing inventory levels in accordance with DODI 4140.39, should utilize as a base all demand observations except those observations for which the requisitions are clearly a one-time acquisition or for those requirements which are forecasted on a basis other than historical demand. One-time acquisitions refer to such demands as retail war reserve requisitions, initial outfitting requisitions, allowance change requisitions, etc."

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT: Computation of Obsolescence Rate

DOD POLICY: DODI 4140.39: Obsolence rate is an element of the cost-to-hold-inventory rate. "Losses due to obsolescence, for the purpose of this Instruction, are intended to include losses of material due to all causes that render the on-hand material superfluous to need.....The obsolescence loss rate is represented as t/a, where:

t = transfers to PDO

a = applicable stratified on-hand and on-order assets on lines A11 and A12 of Table I and on lines B3 and B4 of Table III of stratification.

....."t" represent the fiscal year disposal value....."a" is the average of the applicable assets over the one year preceding...the transfers to PDO.....reviewed annually.....smoothed rate.....unusual losses should be excluded....."

COMPONENT POLICY:

DLA: Obsolescence rate is computed in accordance with DODI 4140.39.

Army: Obsolescence rate is computed in accordance with DODI 4140.39.

Navy: Obsolescence rate is computed:

$$\frac{\sum_{i=1}^{5}[(\text{Disposals})_i+(\Delta\text{PE})_i]-\sum_{i=1}^{6}(\text{MTIS w/o credit})_i f_i}{\sum_{i=1}^{5}(\text{Sales at std. price})_i}$$

where: $f = 0$ if $i = 1$
$.2$ if $i = 2$
$.4$ if $i = 3$
$.6$ if $i = 4$
$.8$ if $i = 5$
1.0 if $i = 6$

Air Force: Accounts for ΔPE and ΔCRS as well as disposals.

DISCUSSION: A discussion of obsolescence in the private sector would probably refer to the difference between the original unit cost and the salvage value of the unit. Furthermore, in the public sector as well as the private sector, obsolescence will likely occur at a point in time (although it may not be predicted with certainty).

It would appear that obsolescence is a time dependent cost; i.e., probability of obsolescence increases as the length of time the item is carried in inventory increases.

DODI 4140.39 does not account for time dependency. Since the disposal value is zero, then in the equation

$$\text{Obsolescence Cost} = \text{rate}(R-\mu+\frac{Q}{2})(\text{unit cost})$$

it is implied that the rate is that portion of the on-hand inventory which is expected to be disposed at some future time.

Due to the OSD moritorium policy on disposal of assets applicable to use by international logistics customers, many assets are being held in the Contingency Retention Stocks (CRS) category. When held in CRS these assets never migrate to the Potential Excess (PE) category, and thus do not become eligible for disposal actions. It would seem these assets should be considered in obsolescence.

Since the Economic Retention Stocks (ERS) category includes those assets which because of economic reasons should be retained, it does not make sense that they should be considered as part of the obsolescence rate if they are expected to be used.

It would seem that changes to PE should also be considered in obsolescence because there may be influencing factors prohibiting the disposal of PE assets (e.g., personnel constraints, funds for shipment to PDO).

In the case of determining the appropriate surcharge for recovering losses due to obsolescence, a sales base should be considered as the denominator of the obsolescence rate equation. The numerator should consider those factors for which sales are never expected (e.g., disposals, ΔPE, ΔCRS).

In the case of determining the holding costs, it would appear the following apply:

a. The storage cost applies to the average on-hand inventory $(R-\mu+\frac{Q}{2})$ and would not be time dependent.
b. The investment cost applies to the average inventory position $(R+\frac{Q}{2})$ and would not be time dependent.
c. The obsolescence cost applies to the average inventory position $(R+\frac{Q}{2})$ and would be time dependent.

d. Other losses inventory cost applies to the average inventory $(R+\frac{Q}{2})$ and would not be time dependent: (e.g., pilferage, theft, loss in shipment).

If those conditions are valid, the formulation of DODI 4140.39 understates the holding costs.

RECOMMENDATION: It is recommended that ASD(MRA&L) resolve this issue in two phases--a short-term phase and a long term phase.

The short-term phase should result in the following policy changes:

a. The holding cost rate is to be applied to the average inventory position $(R+\frac{Q}{2})$ vice the average on-hand inventory $(R-\mu+\frac{Q}{2})$.

b. The obsolescence rate will be computed as an average rate over at least a five year period:

$$\frac{\Sigma(\text{Disp}) + \Sigma(\Delta\text{PE}) + \Sigma(\Delta\text{CRS}) - \Sigma(\text{Returns w/o credit})}{\Sigma(\text{IP})}$$

where:			
	Disp	=	Disposals; transfers to PDO
	ΔPE	=	Change in Potential Excess between successive stratifications
	ΔCRS	=	Change in Contingency Retention Stock between successive stratifications
	Returns w/o credit	=	That portion of material returned to the wholesale level from lower echelons without credit which has become part of the disposal, potential excess or contingency retention stocks
	IP	=	Average inventory position (on-hand plus on-order requirement)

This obsolescence rate computation should be applied to as fine a breakdown of the inventory as possible. This factor should be recognized as an average and should be tempered for such considerations as remaining life of applicable weapon systems, planned equipment modifications, etc.

The long-range phase will depend on the extent to which the development of weapon systems management concepts and the development of new inventory control models proceed. If obsolescence is to be addressed under those topics, consideration should be given to resolving the issue of the time dependency of obsolescence (i.e., the probability of obsolescence occurrence over time).

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT:	Probability Distribution of Leadtime Demand
DOD POLICY:	DODI 4140.39 indicates that F(x+Q ;L) and F(x;L) are the probabilities that the number of units demanded during leadtime (L) are less than or equal to x+Q and x respectively. However DODI 4140.39 does not specify the underlying probability distribution function.

COMPONENT POLICY:

DLA: Assumes the underlying probability distribution of leadtime demand is the Laplace distribution.

Army: Assumes the underlying probability distribution of leadtime demand is the Laplace distribution for items with an average leadtime demand greater than or equal to 20 units and the negative binomial distribution otherwise.

Navy: Assumes the underlying probability distribution of leadtime demand is:

The Poisson distribution for consumable items with quarterly demand averages less than or equal to 0.25 units (Mark 0 items).

The negative binomial distribution for repairable items and for non-Mark 0 consumable items with an average leadtime demand less than or equal to an ICP-set parameter.

The normal distribution for other items.

USAF: Assumes the underlying probability distribution of leadtime demand is the Laplace distribution for consumable items, the negative binomial for repairable items with mean leadtime demand less than or equal to 20 and normal distribution for other repairable items.

DISCUSSION: Since neither DODI 4140.39 nor any other DOD directive specifies the probability distribution of leadtime demand to be used in the computation of safety levels and reorder points, the Components have developed their own rules. Since the Components do not have ADP systems for collecting leadtime demand observations directly and for determining the appropriate distribution empirically, the Components assume probability distributions based primarily on theoretical considerations.

The probability distribution used in safety level calculations can influence the magnitude of the safety level (as can other factors such as leadtime demand variance, shortage cost, etc.).

RECOMMENDATIONS: The world of leadtime demand probability distributions is primarily a theoretical world since none of the Components have observed leadtime demands and fitted curves to those observations. However, the Components have analysis and studies supporting their choices of distributions. The selection of one or more probability distributions as a DOD policy should be the subject of a further study prior to the promulgation of any DOD directive.

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT:	Range Rule for Stockage after Demand Development Period
DOD POLICY:	DODI 4140.39 does not address the subject. Enclosure (3) of DODI 4140.42 addresses the range selection criteria to be used during the initial provisioning process: "Demand-based items:...range of stockage...for items source-coded PA or PC will be based on an economic analysis...COSDIF equation." "All items with an insurance Source Code (PB)...stocked in minimum quantities." "...To maintain a small quantity of...items to be stocked as NSO items, consideration must be given to the essentiality fo the item..."
COMPONENT POLICY:	DLA: Does not have specific criteria for migrating an item from stocked to non-stocked. Does migrate items from non-stocked to stocked based on a basis of *at least 3 demands (for at least 12 units) in 12 months.* Army: Utilizes the COSDIF equation of DODI 4140.42 with a different conditional probability table. Stockage decisions are made monthly, however, an item which migrates from nonstocked to stocked remains so for 12 months before subject to next review. Navy: Does not have specific criteria for migrating an item from nonstocked to stocked status (and vice versa). USAF: Does not have specific criteria for migrating an item from nonstocked to stocked status (and vice versa).
DISCUSSION:	DODI 4140.42 provides a specific mathematical expression for determining, during the provisioning process, whether or not to stock an item as a demand based item. The DODI does permit the use of approved alternative models. In addition, the DODI specifies that nondemand based items are to be stocked in small/minimal quantities when essentiality considerations dictate. There is no DOD policy regarding review of stockage decisions following the Demand Development Period (DDP). As can be seen in the preceding section, each Component has established its own stockage decision rules for items beyond the DDP. However, it seems an

extension of the rules of DODI 4140.42 beyond the DDP is a logical next step in establishing range selection policy regarding secondary items.

RECOMMENDATION: It is recommended that ASD(MRA&L) promulgate a policy statement, regarding stockage of demand based secondary items which are beyond the DDP, as follows:

> "The range rule to be used during and after the Demand Development Period (DDP) is DODI 4140.42 COSDIF or an OSD approved alternative model in which all costs and parameters are consistent with the costs and parameters used in DODI 4140.39 (depth model)."

VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT:	Replacement Cost Used in Models
DOD POLICY:	DODI 4140.39: "C .... the expected acquisition cost as opposed to standard price should be used when feasible."

DODI 7420.1 (Stock Fund Regulations): "The standard price of each item shall include the following elements:

a. The current market or procurement cost of the item at the time a price is established or re-established.

b. Transportation costs authorized to be incurred by stock funds.

c. A surcharge to compensate the stock fund for all normal operating losses on current procurement and for authorized expenses."

DODI 7420.1: "In determining the current market price of an item , it will be necessary to consider the quantity in which it is normally procured ..... The current market price used in establishing the standard price of an item must be supported by evidence such as ..... recent procurement, current manufacturers' price and discount listings, market price quotations or production cost records. In the case of items not being currently procured, the former standard prices shall be continued."

DODI 7200.7 (Major Procurement Appropriations): "Standard prices shall be established for each item of material to include:

a. The current purchase or production cost of the item at the time the price is established.

b. First destination transportation costs."

DODI 7200.7: "The current purchase or production cost..... should be based upon evidence such as current contracts, purchase orders, or invoices, but judgment may be required to arrive at a reasonable current price."

COMPONENT POLICY:	DLA:	The standard unit price is used in the models.
	Army:	The standard unit price is used in the models.
	Air Force:	The order quantity and the Q in the VSL formula are based on standard price less surcharge; the cost in the VSL formula is based on standard price.

Navy: The last contract cost is used in the models.

The above applies to expense items.

DISCUSSION: Looking at the impact of using the standard price vs. the last contract cost (on which the standard price is built). Let us assume that the Component surcharge is 15% and the OSD escalation factor is 9%. Assuming compounding of the factors, there would be an effective standard price 25% larger than the contract cost. For the unconstrained order quantity computations using Wilson EOQ, we see that the cost is in the denominator:

$$\sqrt{\frac{2DA}{IC}}$$

The use of standard price would result in a smaller order quantity than for the last contract cost by a factor of 0.89. For those items already hitting the 3 month minimum constraint, there would be no impact. Looking at the VSL calculation using the K formulation, the impact would be to somewhat increase the VSL/magnitude (with all other factors the same). In the Navy risk formulation, the impact would be to decrease the VSL magnitude (with all other factors the same).

From a purist point-of-view, it would seem that the proper cost to be used would be the cost expected at the next procurement. That cost would "best" be estimated by using the unit cost of the last contract of approximately the order quantity size and escalating it by the approved OSD escalation factors for the time period since the last contract award until the expected time of the next procurement. That "best" estimate is in lieu of information gained directly from the contractor (e.g., catalogs, price lists, information resulting from queries).

Using this "best" estimate approach, let us assume that the appropriate OSD escalation factor is 9%. The use of the "best" estimate versus the last contract cost would result in a smaller order quantity by a factor of 0.958. Assuming a Component surcharge of 15%, the "best" estimate versus the standard price would result in a larger order quantity by a factor of 1.072.

Of course, the magnitude of the difference in the order quantities computed using the 'best' estimate versus the last contract cost or the standard price depends on the escalation factor and surcharge rate used. However, for items which constitute the bulk of the budget funding, the differences are expected to be minimal due to the constraints and due to the items' characteristics.

RECOMMENDATION: The short-term recommendation is not to change anything. For the long term, it is recommended that as the Components have the ADP systems capability, the following policy should be implemented: the replacement cost used in the VSL/EOQ models should be estimated by using the unit cost of the last contract of approximately the same order quantity size and escalating it by approved OSD escalation factors for the time period since the last contract award until the present time.

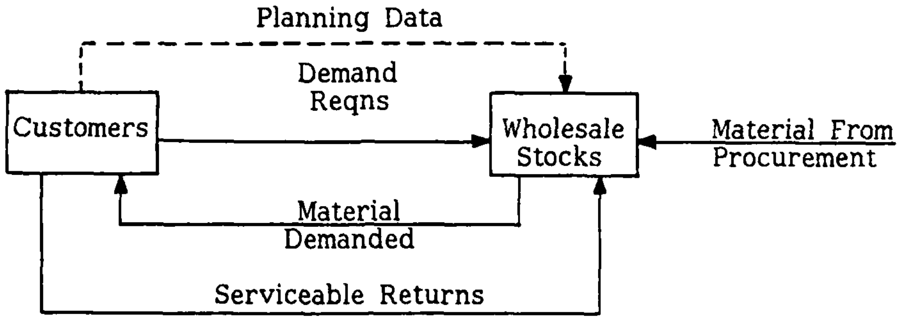
VSL/EOQ SUBGROUP TASK 1 ISSUE

SUBJECT:	Use of Serviceable Returns in Forecasting and Requirements Offsets.	
DOD POLICY:	None formally promulgated to Components.	
COMPONENT POLICY:	DLA:	A Quarterly Returns Forecast (QFR) is computed for each replenishment item which experiences three or more actual return frequencies during the previous year. The QFR or actual returns due-in via the "FTE" process, whichever is greater, is applied as an asset at the time a recommended buy is generated. This has the effect of reducing the buy quantity by the amount of the forecast of returns during the procurement leadtime and procurement cycle periods. In a similar manner, the QFR is applied as an offset in Stratification and budget preparation.
	Army:	The Commodity Command Standard System (CCSS) has the capability to net a portion of the historical serviceable observations from the historical demand observations in the forecasting base. This portion (factor) may be set via a system parameter, a fractional value from 0 to 1, which is controlled at each ICP. In addition to that forecasting offset, actual returns, due-in are counted as assets to offset the procurement requirement, and the item manager may override the ICP system parameter by inputting an item peculiar percentage. Except for one ICP which nets all serviceable returns from demands, the other ICPs utilize factors of 20% or less.
	Navy:	The forecasting routine in the Uniform Inventory Control Point (UICP) system does not forecast serviceable returns or offset demand forecasts with serviceable returns. Servicable returns anticipated via the "FTE" process are considered due-in and are counted as assets to any procurement or repair requirement in Stratification or actual procurement and repair actions.
	Air Force:	In the historical data base, eight quarters of serviceable returns are maintained for all items. For items with more than $5000 value of average annual demands, the returns over the forecasting base period are subtracted from the recurring demands in the forecasting base period to give net demands for each quarter. These net demand observations are then used in forecasting means (averages) and variances for budget formulation and execution. Serviceable return observations are not used to net demand in forecasting for items with $5000 or less value of average annual demand.

DISCUSSION: In addition to being raised during the VSL/EOQ implementation discussions of the DOD Stockage Policy Analysis effort, the use of serviceable return forecasts and offsets was addressed in GAO Report DM-80-3, 943052, OSD Case 5365.

There are two areas involved in forecasting serviceable returns: Budget formulation (stratification) and budget execution (procurement/repair reviews). The stratification horizon is 2+ years while the execution horizon is a procurement and repair leadtime.

A simple picture of the consumable item process is:



From the picture, it is seen that in actual occurrence the demand requisitions are satisfied from material received from procurement actions and serviceable returns. The problem is in forecasting the process.

Serviceable returns may or may not occur in a regular, continual process. If they do, it is reasonable that they be forecasted. If they don't, forecasting them could be very unreliable. Serviceable returns may or may not occur from demands which are in the forecasting base. If they are, it is reasonable that they be forecasted and taken as offsets to the demand forecast. The serviceable return offset could be either a reduction to the demand directly or an expected receipt of assets. It is DLA's position that serviceable returns, actual or forecast, should be treated as assets rather than as a direct offset to demands. It is Navy's position that the source of serviceable returns comes largely from allowance list changes for which the original demands are not part of the forecasting base and should not be forecasted as demand offsets. Army and Air Force do utilize serviceable returns as offsets.

It should be noted now that, throughout this discussion, the offsetting of demand with serviceable returns to arrive at a net demand involves the difference of two random variables--demand (X) and serviceable returns (Y). From probability

theory we know that $E(X-Y) = E(X) - E(Y)$ and $Var (X-Y) = Var (X) + Var (Y) - 2 Cov (X,Y)$. If we make the simplifying assumption that demands and serviceable returns are independent random variables, Var (Net Demands) = Var (Demands) + Var (Serviceable Returns). This variance, used in computing safety level requirements, is a larger variance value than if serviceable returns are not already so accounted. On the other hand, under the apparent assumption of GAO that demands and serviceable returns are correlated, the formula for the variance of net demand incorporates a cumbersome covariance term.

RECOMMENDATION: Since the Components do not have similar demands in their forecasting bases and would resolve the problem using different approaches, it is recommended that this issue be resolved by ASD (MRA&L) as a long range effort in the following manner:

a. Task each Component to study the feasibility of forecasting serviceable returns and utilizing such forecasts as offsets to demand forecasts and/or as assets. The study should include:

1. Consumable and repairable items.
2. Stratification and budget execution.
3. Kinds/types of demands in forecasting base (i.e., outfittings/nonrecurring; intermediate stock replenishment /recurring; etc.)
4. Serviceable return patterns with examples illustrating frequency, randomness, etc.
5. Sources of serviceable returns and quantities (e.g., shipboard allowance changes).

b. Task each Component to present the results of the study via a presentation to ASD (MRA&L) staff.

c. ASD (MRA&L) staff analyze the differences among the Components and then call for a small working group to develop a DOD policy statement.

VSL/EOQ SUBGROUP TASK 2 ISSUE

SUBJECT:	Controls over VSL/EOQ Parameters and Constraints
DOD POLICY:	Parameters and constraints, used in computing VSL and EOQ values for consumable items, which are described in DODI 4140.39, are the shortage parameter (λ), the variable cost to hold rate (I), the variable cost to order (A), the procurement cycle constraints of a minimum of 3 months and a maximum of 3 years and the safety level constraint of a maximum of three standard deviations of leadtime demand or the mean leadtime demand, whichever is less. In addition, DODI 4140.39 permits the optional constraint of a zero safety level in those instances where a negative safety level would be computed. DOD policy does not cover controls, at the OSD or Components' Headquarter levels, over the setting of values for the parameters and constraints.
COMPONENT POLICY:	As shown at Annex A Part 2, the Components have various parameters and constraints in their implementation of DODI 4140.39. In nearly all instances, the values for the parameters and constraints are determined by the respective ICP (or other Component agency) and are reviewed and approved by logistics headquarters level within the Component.
DISCUSSION:	Based on information provided by the Components, it is determined that the controls over parameter and constraint settings are adequate. Within each Component, the values determined by the ICPs are reviewed and approved by at least the next higher level of authority in the respective ICP chain-of-command.
RECOMMENDATION:	It is recommended that OASD(MRA&L) issue a policy statement (as Part of DODI 4140.39 or other pertinent DOD directive) which states:

"Values for key parameters and constraints, utilized in the computation of safety level and procurement cycle requirements and determined at a level of authority below the Component logistics headquarters (e.g. DLAHQ, AFLCHQ, NAVMATHQ/ NAVSUPHQ, DARCOMHQ), are to be reviewed and approved by the Component logistics headquarters. Examples of such parameters and constraints are: shortage cost, cost to hold rate, cost to order, acceptable risk limits, acceptable order limits, acceptable safety level limits. etc."

VSL/EOQ SUBGROUP TASK 3 ISSUE

SUBJECT: Simulation Comparison

BACKGROUND: ASD(MRA&L-SR) memorandum of 4 December 1979 assigned a detailed set of tasks to a Working Group composed of Component and OSD representatives. The third task assigned to the VSL/EOQ Subgroup was to determine the contribution of VSL/EOQ models to long supply. This task was to be accomplished via a simulation. Subsequent to the original tasking the OMB representative to the Steering Group indicated a desire that the Working Group exchange simulation data bases and rerun the simulations, presumably to compare the impact of the different models. Subsequent VSL/EOQ Subgroup discussions and analysis lead to the conclusion that, although an exhange of data could be accomplished in the long term, an exchange is not feasible without overcoming nearly insurmountable differences in simulators and data bases. Those findings and the alternative approach of an exchange of models were documented in Chairman, VSL/EOQ Subgroup letter 013/LRA 210-172 of March 1980 to Chairman, Working Group.

DISCUSSION: To determine the scope of a long term effort to exchange models, each VSL/EOQ Subgroup representative examined past Component studies and analyses related to forecasting and inventory levels requirements models. These examinations were to identify previous comparisons of model's impact on inventories which could be used to limit the effort necessary to accomplish ADP program changes necessary to measure the impact of alternative models. The examinations led to the conclusion that the exchange of models for a simulation effort would entail most of the areas recommended to be addressed as long range studies in the Task No. 1 issues.

RECOMMENDATION: In view of the long range study recommendations for resolving policy issues concerning demand forecasting, probability distribution assumptions, serviceable returns forecasting and EOQ constraints, it is recommended that any study concerning an exchange of models be completed in conjunction with those long rang studies.

2.0 VSL/EOQ SIMULATIONS

VSL/EOQ Long Supply Simulation

During the Office of Management and Budget (OMB) review of the FY 1980 Defense Budget, the OMB staff raised several supply system "efficiency" issues. One of these issues concerned the amount of materiel annually recategorized to excess (long supply) stocks. Specifically, OMB alleged that ten percent of the dollar value of materiel acquired through new procurement and repair costs is annually categorized as potential excess and contingency inventory levels. The OMB staff desired that DoD determine the degree to which the VSL/EOQ policies implemented by the DoD Components contribute to long supply.

In order to examine the flow of materiel into excess (long supply) that is due to VSL/EOQ policy implementation, a simulation effort utilizing a large sample of demand based consumable items was undertaken by the Working Group. Each DoD Component used a simulator that emulated the forecasting and VSL/EOQ models employed in their implementation of DoD Instruction 4140.39 and simulated the respective wholesale supply system operations over the simulation horizon. Simulations, using actual demand histories to the extent feasible, were made at various inventory level parameter settings to evaluate the impact of various operating policies. A detailed description of each Component's effort, including the various output statistics, is provided later in this Annex.

Briefly stated, the Components' simulations confirmed that the VSL/EOQ and forecasting models used by the Components do contribute to the generation of long supply assets, particularly during periods of prolonged declining demand. Also, the simulations indicated that, as the investment in safety level increases, the liklihood that excess stocks will be generated also increases. The degree to which these factors contribute to long supply in the "real world" could not be precisely determined because of several highly dependent conditions which were present in the simulations (e.g. demand trends, inventory level changes, leadtime assumptions, etc.). However, an examination of actual versus forecasted demands and a comparison of the Services' long supply generation versus DLA long supply led to the conclusion that

the forecasting methodology has been the predominant factor contributing to long supply (rather than the VSL/EOQ models or the parameter settings used by the Components).

Since the study did not include a comparison of the Components VSL/EOQ levels and forecasting models per se, it could not be determined which models in use today would perform "best" with respect to long supply generation and supply effectiveness measures. Such an effort would have to be undertaken as a much broader follow-on study.

The following sections document each Component's long supply simulation work.

AIR FORCE VSL/EOQ SIMULATION

VSL/EOQ TASK NO. 0003

A. Scope and Methods

This study was conducted to evaluate the impact of the Air Force VSL/EOQ models on long supply and materiel support. The study was limited to consumable, demand based, secondary items. The Air Force Inventory System Simulator, a working tool used in wholesale stockage levels, was used to test and quantify the impact of various inventory control policies for this study.

Three random samples of 1000 items were selected from historical records of the Economic Order Quantity Buy Computation System (D062) of two Air Logistics Centers (ALCs). The historical data drawn covered the period of Fiscal Year 1971 through Fiscal Year 1979 for the Oklahoma City (OC) and Sacramento (SM) ALCs.

The characteristics of each of these samples are presented at Appendix A. The item samples were predominantly from Federal Stock Classes 1560, 1650, 1660 and 2995. For the two Oklahoma City samples, a variety of aircraft were represented in both samples. The Sacramento Air Logistics Center sample, on the other hand, contained items which supported only two aircraft, the F105 and the T39.

The Inventory System Simulator provides a detailed description of the Economic Order Quantity Buy Computation System (D062), and utilizes actual D062 demand histories to drive the simulation process. Major rules used in the simulation runs include:

> Total unit demands per quarter exactly equal the D062 historical values. However, Monte Carlo techniques are used to generate the specific sizes of individual requisitions. Both high and low priority requisitions are simulated, and there is

a 50% chance that any given requisition is a high priority demand. All demands are assumed to be recurring type demands.

Forecasts of item demand rates and associated safety levels, reorder points, and order quantities are updated each quarter. Demand forecasts are based on an eight quarter moving average, with proportional adjustments for forecast changes in flying program activity.

Safety stocks and EOQ quantities are computed using the Air Force VSL/EOQ model implementing DoD Instruction 4140.39 and are based upon the Presutti-Trepp formulas employed in the D062 system. Safety stocks are bounded to lie between 0 and lesser of either expected demands in the lead time or three times the standard deviation of demands in the lead time. EOQ quantities are bounded to lie between 6 and 36 times the monthly demand rates.

Lead times and unit costs are assumed to be known and constant throughout simulation. The delivery of a procurement is simulated to occur a procurement leadtime after the buy is generated.

Initial on hand stocks are set equal to the expected demand over the leadtime for every item simulated. Initial on order stocks are set equal to zero. This assumption assures that no item is in an excess position in the beginning of the simulation run.

A total of 38 quarters of data were available from the D062 history records. This data covered the period beginning with the first quarter of FY 71 and continued through FY 79. The primary item data extracted from the historical records and used in the simulation runs were weapon system relationships and the units of demand by quarter. Eight

quarters of this data were used to initialize the historical arrays and demand rate estimates, and 30 quarters were used to simulate the dynamic behavior of the system. Consequently, the simulation evaluates how each of the proposed rules would have performed had they been employed beginning with the first quarter of Fiscal Year 1973.

Each item sample was used in six separate simulation runs. In one run, the safety level was set to zero throughout the simulation. In the five remaining runs, the current D062 system safety level rules were employed with shortage cost values of .1, 100, 390 (for OC) or 555 (for SM), 1000, and 100,000. A shortage cost factor of $390/backorder is the value currently employed at the Oklahoma City ALC, while a value of $555/backorder is currently used at Sacramento.

For this analysis, the simulator was modified to provide output statistics at the end of each quarter following the eight quarter warm-up period. The statistics included the requisition fill rate during each quarter, the requisition fill rate achieved from the start of the simulation, the average days delay during each quarter, the average days delay achieved from the start of the simulation, the dollar value of on-hand and on-order assets at the end of each quarter, the dollar value of the safety level requirement during each quarter, the dollar value of procurements from the start of the simulation, the dollar value of long supply assets at the end of each quarter, and the percentage of long supply with respect to procurements at the end of each quarter. Long supply for these simulations was composed of assets in excess of the requirements objective plus two years of forecasted demand. This simple measure was chosen to emulate the measure of long supply in stratification. Note that the measure of long supply is very much a function of the forecasted demand rate.

Appendices B through D provide tables and graphs reflecting the results of the simulation. Appendix B provides data for the Oklahoma City ALC high dollar value sample; Appendix C, the Oklahoma City ALC low dollar value sample; and Appendix D, the Sacramento ALC sample.

There are two formats of tabular data. Table 1 of the Appendices provides a snapshot of the output measurements for each of six simulation runs (i.e. zero safety level and shortage costs of \$.10, \$100, \$390 at Oklahoma City, \$555 at Sacramento, \$1000, and \$100,000) at six month increments after the start of the simulation runs. Tables 2 through 8 display the same data in a different format that shows the results of all runs for every quarterly time interval for each output measure. Table 9 shows the dollar value generation of new procurement versus the dollar value generation of long supply at year increments for the run at shortage cost of \$390 at Oklahoma City and \$555 at Sacramento. Table 10 shows a marginal analysis of changes in shortage cost to changes in the various output measures. Graph 1 displays the trend in requisistions over the simulation period. Graphs 2 through 4 display plots of the relationships of primary interest measures at the end of the simulation:

- o Dollar value of long supply versus dollar value of procurement (cumulative).

- o Requisition fill rate versus average dollar value of long supply.

- o Average days delay versus average dollar value of long supply.

B. Findings and Conclusions

In all item samples, total demand drops significantly during the Fiscal Year 1971-1979 interval, as shown on Graph 1 of Appendices B-D. At the beginning of this period, the Vietnam war was underway, and flying programs and usage were significantly higher than during the last half of the decade. Although the simulation rules assured there were no excesses at the start of the simulation runs, the decreasing level of demand coupled with forecasts of further demand decreases resulted in stocking objectives that dropped much faster than assets;

see Tables 7 and 8 of the Appendices. The result was significant levels of excess at the end of the simulation for all item samples and all safety level objectives.

Very high fill rates were achieved in most of the simulation runs; see Table 2 of Appendices B-D. This appears to be due to three major causes: (a) the general decline in demand produced overstock conditions for a majority of items, (b) setting inital on-hand stocks equal to expected leadtime demand resulted in excellent support during the first few years of the simulation, and finally, (c) the 'constant leadtime' assumption eliminated the possibility of late deliveries being simulated.

As shown in Table 6 of the Appendices, the probability of assets migrating to long supply increases as the safety level increases due to adjustments in the shortage cost parameter. However, as shown in Table 10 and Graph 4 of Appendices B-D, the rate of increase slows as safety level is increased.

APPENDIX A

TABLE I

CHARACTERISTICS OF ITEM SAMPLES

Sample	Number of Items	Air Logistics Center	Annual Dollar Demands in FY71 - FY72	Major Federal Stock Classes Represented	Major Aircraft Supported
OC1H	1,000	Oklahoma City	$10,000/yr or more	1650 1660 2995	B52 F4 T29 C130 F100 T38 C135 F102 C141 F104
OC1L	1,000	Oklahoma City	$500/yr - $10,000/yr	1660 1660	B52 F5 F104 C135 F/FB111 and F4 F102 several others
SM1L	1,000	Sacramento	$100/yr - $10,000/yr	1560	F105 T39

TABLE II

FEDERAL STOCK CLASSES SIMULATED

FEDERAL STOCK CLASS	DESCRIPTION
1560	Aircraft Structural Components (SM)
1650	Aircraft Hydraulic, Vacuum and De-Icing System Components (OC)
1660	Aircraft Air Conditioning, Heating and Pressurizing Equipment (OC)
2995	Miscellaneous Engine Accessories, Aircraft (OC)

APPENDIX B

TABLE 1 APPENDIX B

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.10	100	390	1,000	100,000
SIMULATION + 6 MONTHS						
REQUISITION FILL RATE	0.98	0.98	0.98	0.99	0.99	0.99
AVERAGE DAYS DELAY	0.89	0.89	0.89	0.89	0.89	0.89
$ CUM. BUYS	51.45	51.45	53.79	62.44	71.23	86.49
$ LONG SUPPLY (LS)	0.03	0.03	0.10	0.11	0.16	0.20
$ LS ÷ $ CUM. BUYS	0.001	0.001	0.002	0.002	0.002	0.002
$ SAFETY LEVEL	0	0	1.94	9.44	17.37	31.13
$ ON HAND + ON ORDER	44.48	44.48	46.82	55.47	64.26	79.52
SIMULATION + 12 MONTHS						
REQUISITION FILL RATE	0.93	0.93	0.93	0.93	0.93	0.93
AVERAGE DAYS DELAY	5.58	5.58	5.28	4.94	4.83	4.78
$ CUM. BUYS	66.52	66.52	68.35	75.95	84.95	102.53
$ LONG SUPPLY (LS)	0.38	0.38	0.48	0.78	1.10	1.32
$ LS ÷ $ CUM. BUYS	0.006	0.006	0.007	0.010	0.013	0.013
$ SAFETY LEVEL	0	0	1.48	7.97	15.75	29.68
$ ON HAND + ON ORDER	47.74	47.74	49.49	56.91	65.82	83.29
SIMULATION + 18 MONTHS						
REQUISITION FILL RATE	0.89	0.89	0.90	0.91	0.92	0.93
AVERAGE DAYS DELAY	11.42	11.42	9.82	8.39	7.68	7.34
$ CUM. BUYS	76.10	76.10	77.62	84.81	93.93	112.65
$ LONG SUPPLY (LS)	1.03	1.03	1.25	1.79	2.34	3.14
$ LS ÷ $ CUM. BUYS	0.014	0.014	0.016	0.021	0.025	0.028
$ SAFETY LEVEL	0	0	1.03	6.36	13.66	28.36
$ ON HAND + ON ORDER	47.91	47.91	49.01	55.36	64.02	82.50
SIMULATION + 24 MONTHS						
REQUISITION FILL RATE	0.88	0.88	0.90	0.92	0.93	0.93
AVERAGE DAYS DELAY	14.18	14.18	11.85	9.19	7.67	6.83
$ CUM. BUYS	85.36	85.36	86.63	93.39	102.69	122.35
$ LONG SUPPLY (LS)	1.83	1.83	2.13	2.93	3.77	5.63
$ LS ÷ $ CUM. BUYS	0.021	0.021	0.025	0.031	0.037	0.046
$ SAFETY LEVEL	0	0	0.68	5.16	12.25	27.81
$ ON HAND + ON ORDER	46.84	46.84	47.96	54.12	62.85	82.05
SIMULATION + 30 MONTHS						
REQUISITION FILL RATE	0.88	0.88	0.90	0.92	0.93	0.94
AVERAGE DAYS DELAY	14.21	14.21	11.83	8.91	7.09	6.04
$ CUM. BUYS	94.40	94.40	95.34	101.36	109.99	131.93
$ LONG SUPPLY (LS)	2.17	2.17	2.55	3.65	4.85	6.84
$ LS ÷ $ CUM. BUYS	0.023	0.023	0.027	0.036	0.044	0.052
$ SAFETY LEVEL	0	0	0.32	3.57	9.66	26.39
$ ON HAND + ON ORDER	45.51	45.51	46.31	52.06	60.27	81.79

T A B L E 1

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.10	100	390	1,000	100,000
SIMULATION + 36 MONTHS						
REQUISITION FILL RATE	0.88	0.88	0.90	0.92	0.94	0.95
AVERAGE DAYS DELAY	13.98	13.98	11.66	8.65	6.64	5.37
$ CUM. BUYS	103.32	103.32	104.11	109.65	118.27	140.15
$ LONG SUPPLY (LS)	2.98	2.98	3.37	4.78	6.63	11.02
$ LS ÷ $ CUM. BUYS	0.029	0.029	0.032	0.044	0.056	0.079
$ SAFETY LEVEL	0	0	0.28	3.32	8.67	24.00
$ ON HAND + ON ORDER	44.91	44.91	45.59	50.85	58.95	80.22
SIMULATION + 42 MONTHS						
REQUISITION FILL RATE	0.88	0.88	0.90	0.92	0.94	0.95
AVERAGE DAYS DELAY	14.19	14.19	11.88	8.68	6.45	4.91
$ CUM. BUYS	110.16	110.16	110.90	116.53	124.69	146.61
$ LONG SUPPLY (LS)	3.98	3.98	4.32	6.05	8.36	13.52
$ LS ÷ $ CUM. BUYS	0.036	0.036	0.039	0.052	0.067	0.092
$ SAFETY LEVEL	0	0	0.24	2.91	7.78	21.57
$ ON HAND + ON ORDER	42.33	42.33	42.98	48.25	55.82	77.03
SIMULATION + 48 MONTHS						
REQUISITION FILL RATE	0.87	0.87	0.89	0.92	0.94	0.96
AVERAGE DAYS DELAY	14.57	14.57	12.34	8.71	6.27	4.53
$ CUM. BUYS	122.36	122.36	122.99	128.16	135.98	158.38
$ LONG SUPPLY (LS)	4.06	4.06	4.40	5.96	8.27	12.84
$ LS ÷ $ CUM. BUYS	0.033	0.033	0.036	0.047	0.061	0.081
$ SAFETY LEVEL	0	0	0.23	3.03	8.12	23.78
$ ON HAND + ON ORDER	44.92	44.92	45.44	50.17	57.62	79.08
SIMULATION + 54 MONTHS						
REQUISITION FILL RATE	0.87	0.87	0.89	0.92	0.94	0.96
AVERAGE DAYS DELAY	15.41	15.41	13.11	9.00	6.30	4.29
$ CUM. BUYS	131.37	131.37	131.94	136.66	144.08	167.16
$ LONG SUPPLY (LS)	4.54	4.54	4.84	6.26	8.45	13.61
$ LS ÷ $ CUM. BUYS	0.035	0.035	0.037	0.046	0.059	0.081
$ SAFETY LEVEL	0	0	0.25	3.03	7.77	22.76
$ ON HAND + ON ORDER	44.08	44.08	44.57	48.62	55.52	77.73
SIMULATION + 60 MONTHS						
REQUISITION FILL RATE	0.86	0.86	0.88	0.91	0.94	0.96
AVERAGE DAYS DELAY	16.59	16.59	14.12	9.45	6.46	4.17
$ CUM. BUYS	141.12	141.12	141.62	146.33	153.61	177.01
$ LONG SUPPLY (LS)	5.21	5.21	5.52	6.94	9.10	14.39
$ LS ÷ $ CUM. BUYS	0.037	0.037	0.039	0.047	0.059	0.081
$ SAFETY LEVEL	0	0	0.27	3.05	7.76	22.60
$ ON HAND + ON ORDER	44.55	44.55	44.94	49.17	55.76	78.21

TABLE 1

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.10	100	390	1,000	100,000
SIMULATION + 66 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.94	0.96
AVERAGE DAYS DELAY	17.18	17.18	14.67	9.67	6.45	3.98
$ CUM. BUYS	150.04	150.04	150.64	155.19	162.76	185.42
$ LONG SUPPLY (LS)	5.69	5.69	5.97	7.41	9.85	15.47
$ LS ÷ $ CUM. BUYS	0.038	0.038	0.040	0.048	0.061	0.083
$ SAFETY LEVEL	0	0	0.26	3.00	7.53	22.01
$ ON HAND + ON ORDER	42.83	42.83	43.37	47.55	54.55	76.57
SIMULATION + 72 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.94	0.96
AVERAGE DAYS DELAY	17.45	17.45	15.07	9.85	6.43	3.83
$ CUM. BUYS	157.46	157.46	157.99	162.34	169.93	193.03
$ LONG SUPPLY (LS)	6.74	6.74	7.01	8.45	10.89	17.09
$ LS ÷ $ CUM. BUYS	0.043	0.043	0.044	0.052	0.064	0.089
$ SAFETY LEVEL	0	0	0.23	2.75	7.11	20.41
$ ON HAND + ON ORDER	41.24	41.24	41.75	45.69	52.74	75.46
SIMULATION + 78 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.94	0.96
AVERAGE DAYS DELAY	17.64	17.64	15.36	10.05	6.38	3.66
$ CUM. BUYS	165.91	165.91	166.42	170.63	177.83	200.21
$ LONG SUPPLY (LS)	7.07	7.07	7.33	8.83	11.38	17.16
$ LS ÷ $ CUM. BUYS	0.043	0.043	0.044	0.052	0.064	0.086
$ SAFETY LEVEL	0	0	0.20	2.51	6.70	19.59
$ ON HAND + ON ORDER	39.94	39.94	40.41	44.30	51.14	73.16
SIMULATION + 84 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.86	0.90	0.94	0.97
AVERAGE DAYS DELAY	17.79	17.79	15.57	10.14	6.31	3.51
$ CUM. BUYS	173.72	173.72	174.20	178.29	185.63	207.29
$ LONG SUPPLY (LS)	7.81	7.81	8.10	9.69	12.45	18.96
$ LS ÷ $ CUM. BUYS	0.045	0.045	0.047	0.054	0.067	0.091
$ SAFETY LEVEL	0	0	0.13	2.26	6.33	1.84
$ ON HAND + ON ORDER	39.88	39.88	40.33	44.16	51.01	71.96
SIMULATION + 90 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.86	0.90	0.94	0.97
AVERAGE DAYS DELAY	17.91	17.91	15.74	10.30	6.38	3.43
$ CUM. BUYS	182.65	182.65	183.03	187.07	194.84	216.98
$ LONG SUPPLY (LS)	8.35	8.35	8.65	10.27	13.01	20.02
$ LS ÷ $ CUM. BUYS	0.046	0.046	0.047	0.055	0.067	0.092
$ SAFETY LEVEL	0	0	0.12	1.88	6.68	19.19
$ ON HAND + ON ORDER	40.65	40.65	41.02	44.86	52.13	73.57

TABLE 2

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

REQUISITION FILL RATE

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
			CUMULATIVE			
1	0.99	0.99	0.99	0.99	0.99	0.99
2	0.98	0.98	0.98	0.98	0.98	0.98
3	0.95	0.95	0.95	0.96	0.96	0.96
4	0.93	0.93	0.93	0.93	0.93	0.93
5	0.90	0.90	0.91	0.92	0.92	0.92
6	0.89	0.89	0.90	0.91	0.92	0.93
7	0.88	0.88	0.90	0.91	0.92	0.93
8	0.88	0.88	0.90	0.92	0.93	0.93
9	0.88	0.88	0.90	0.92	0.93	0.94
10	0.88	0.88	0.90	0.92	0.93	0.94
11	0.88	0.88	0.90	0.92	0.94	0.95
12	0.88	0.88	0.90	0.92	0.94	0.95
13	0.88	0.88	0.90	0.92	0.94	0.95
14	0.88	0.88	0.90	0.92	0.94	0.95
15	0.88	0.88	0.89	0.92	0.94	0.96
16	0.87	0.87	0.89	0.92	0.94	0.96
17	0.87	0.87	0.89	0.92	0.94	0.96
18	0.87	0.87	0.89	0.92	0.94	0.96
19	0.86	0.86	0.88	0.91	0.94	0.96
20	0.86	0.86	0.88	0.91	0.94	0.96
21	0.86	0.86	0.88	0.91	0.94	0.96
22	0.85	0.85	0.87	0.91	0.94	0.96
23	0.85	0.85	0.87	0.91	0.94	0.96
24	0.85	0.85	0.87	0.91	0.94	0.96
25	0.85	0.85	0.87	0.91	0.94	0.96
26	0.85	0.85	0.87	0.91	0.94	0.96
27	0.85	0.85	0.86	0.90	0.94	0.97
28	0.85	0.85	0.86	0.90	0.94	0.97
29	0.85	0.85	0.86	0.90	0.94	0.97
30	0.85	0.85	0.86	0.90	0.94	0.97

L = SHORTAGE COST

TABLE 3

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

AVERAGE DAYS DELAY - - - REQUISITIONS

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
			CUMULATIVE			
1	0.14	0.14	0.14	0.14	0.14	0.14
2	0.89	0.89	0.89	0.89	0.89	0.89
3	2.66	2.66	2.61	2.57	2.55	2.54
4	5.58	5.58	5.28	4.94	4.83	4.78
5	8.62	8.62	7.80	7.04	6.12	6.57
6	11.42	11.42	9.82	8.39	7.68	7.34
7	13.31	13.31	11.19	9.01	7.84	7.22
8	14.18	14.18	11.85	9.19	7.67	6.83
9	14.36	14.36	11.95	9.11	7.38	6.41
10	14.21	14.21	11.83	8.91	7.09	6.04
11	13.99	13.99	11.65	8.73	6.83	5.68
12	13.98	13.98	11.66	8.65	6.64	5.37
13	14.11	14.11	11.77	8.67	6.55	5.12
14	14.19	14.19	11.88	8.68	6.45	4.91
15	14.30	14.30	12.05	8.67	6.33	4.70
16	14.57	14.57	12.34	8.71	6.27	4.53
17	15.00	15.00	12.72	8.87	6.28	4.42
18	15.41	15.41	13.11	9.00	6.30	4.29
19	16.01	16.01	13.64	9.23	6.37	4.23
20	16.59	16.59	14.12	9.45	6.46	4.17
21	17.02	17.02	14.48	9.61	6.46	4.09
22	17.18	17.18	14.67	9.67	6.45	3.98
23	17.31	17.31	14.85	9.75	6.44	3.91
24	17.45	17.45	15.07	9.85	6.43	3.83
25	17.58	17.58	15.25	9.98	6.42	3.75
26	17.64	17.64	15.36	10.05	6.38	3.66
27	17.71	17.71	15.45	10.08	6.34	3.57
28	17.79	17.79	15.57	10.14	6.31	3.51
29	17.84	17.84	15.65	10.21	6.34	3.46
30	17.91	17.91	15.74	10.30	6.38	3.43

L = SHORTAGE COST

TABLE 4

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

CUMULATIVE PROCUREMENT
(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
			CUMULATIVE			
1	45.7	45.7	48.1	56.8	65.3	80.1
2	51.5	51.5	53.8	62.4	71.2	86.5
3	59.7	59.7	61.6	69.6	78.6	95.0
4	66.5	66.5	68.3	76.0	84.9	102.5
5	71.6	71.6	73.2	80.5	89.6	107.8
6	76.1	76.1	77.6	84.8	93.9	112.6
7	81.8	81.8	83.2	90.2	99.4	118.8
8	85.4	85.4	86.6	93.4	102.7	122.4
9	89.7	89.7	90.8	97.1	106.2	126.6
10	94.4	94.4	95.3	101.4	110.0	131.9
11	99.3	99.3	100.1	105.7	113.7	135.4
12	103.3	103.3	104.1	109.7	118.3	140.1
13	106.0	106.0	106.8	112.4	120.9	142.6
14	110.2	110.2	110.9	116.5	124.7	146.6
15	115.4	115.4	116.0	121.4	129.9	151.8
16	122.4	122.4	123.0	128.2	136.0	158.4
17	126.8	126.8	127.5	132.5	140.3	163.2
18	131.4	131.4	131.9	136.7	144.1	167.2
19	136.6	136.6	137.1	141.7	146.3	153.6
20	141.1	141.1	141.6	146.3	153.6	177.0
21	145.1	145.1	145.7	150.2	157.5	180.8
22	150.0	150.0	150.6	155.2	162.8	185.4
23	154.2	154.2	154.7	158.9	166.4	190.0
24	157.5	157.5	158.0	162.3	170.0	193.0
25	161.3	161.3	161.8	166.1	173.6	194.2
26	165.9	165.9	166.4	170.6	177.8	200.2
27	169.6	169.6	170.1	174.1	181.7	203.5
28	173.7	173.7	174.2	178.3	185.6	207.3
29	177.1	177.1	177.6	181.6	188.9	211.3
30	182.6	182.6	183.0	187.1	194.8	217.0

L = SHORTAGE COST

TABLE 5

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

END OF PERIOD LONG SUPPLY
(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1	0	0	0	0	0	0
2	0	0	.1	.1	.2	.2
3	.2	.2	.2	.4	.7	1.2
4	.4	.4	.5	.8	1.1	1.3
5	.8	.8	.9	1.4	1.9	2.7
6	1.0	1.0	1.3	1.8	2.3	3.1
7	1.2	1.2	1.4	2.1	2.7	4.2
8	1.8	1.8	2.1	2.9	3.8	5.6
9	2.0	2.0	2.3	3.2	4.2	6.2
10	2.2	2.2	2.6	3.7	4.9	6.8
11	2.7	2.7	3.1	4.4	6.0	9.1
12	3.0	3.0	3.4	4.8	6.6	11.0
13	3.5	3.5	3.8	5.4	7.6	12.6
14	4.0	4.0	4.3	6.0	8.4	13.5
15	3.8	3.8	4.2	5.8	8.0	12.2
16	4.1	4.1	4.4	6.0	8.3	12.8
17	4.4	4.4	4.7	6.2	8.3	13.2
18	4.5	4.5	5.8	6.3	8.4	13.6
19	4.8	4.8	5.1	6.5	8.6	13.8
20	5.2	5.2	5.5	6.9	9.1	14.4
21	5.5	5.5	5.8	7.2	9.5	15.1
22	5.7	5.7	6.0	7.4	9.9	15.5
23	6.2	6.2	6.4	7.9	10.2	16.0
24	6.7	6.7	7.0	8.5	10.9	17.1
25	6.9	6.9	7.2	8.6	11.1	17.7
26	7.1	7.1	7.3	8.8	11.4	17.2
27	7.4	7.4	7.6	9.2	12.0	17.9
28	7.8	7.8	8.1	9.7	12.4	19.0
29	8.3	8.3	8.6	10.2	13.1	20.0
30	8.3	8.3	8.6	10.3	13.0	20.0

L = SHORTAGE COST

TABLE 6

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

RATIO OF EOP LONG SUPPLY $ TO CUM BUY $

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1	0	0	0	0	0	0
2	0.001	0.001	0.002	0.002	0.002	0.002
3	0.003	0.003	0.004	0.006	0.009	0.012
4	0.006	0.006	0.007	0.010	0.013	0.013
5	0.011	0.011	0.013	0.017	0.022	0.025
6	0.014	0.014	0.016	0.021	0.025	0.028
7	0.014	0.014	0.017	0.023	0.027	0.035
8	0.021	0.021	0.025	0.031	0.037	0.046
9	0.022	0.022	0.026	0.033	0.039	0.049
10	0.023	0.023	0.027	0.036	0.044	0.052
11	0.028	0.028	0.031	0.042	0.053	0.067
12	0.029	0.029	0.032	0.044	0.056	0.079
13	0.033	0.033	0.036	0.048	0.063	0.088
14	0.036	0.036	0.039	0.052	0.067	0.092
15	0.033	0.033	0.036	0.047	0.062	0.081
16	0.033	0.033	0.036	0.047	0.061	0.081
17	0.035	0.035	0.037	0.047	0.059	0.081
18	0.035	0.035	0.037	0.046	0.059	0.081
19	0.035	0.035	0.037	0.046	0.058	0.080
20	0.037	0.037	0.039	0.047	0.059	0.081
21	0.038	0.038	0.040	0.048	0.060	0.084
22	0.038	0.038	0.040	0.048	0.061	0.083
23	0.040	0.040	0.042	0.049	0.061	0.084
24	0.043	0.043	0.044	0.052	0.064	0.089
25	0.043	0.043	0.044	0.052	0.064	0.090
26	0.043	0.043	0.044	0.052	0.064	0.086
27	0.043	0.043	0.045	0.053	0.066	0.088
28	0.045	0.045	0.047	0.054	0.067	0.091
29	0.047	0.047	0.048	0.056	0.069	0.094
30	0.046	0.046	0.047	0.055	0.067	0.092

L = SHORTAGE COST

TABLE 7

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

SAFETY LEVEL REQUIREMENT BY QUARTER
(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1			2.2	10.2	18.5	32.8
2			1.9	9.4	17.4	31.1
3			1.7	8.6	16.5	30.2
4			1.4	8.0	15.7	29.7
5			1.2	7.0	14.2	28.3
6			1.0	6.5	13.7	28.4
7			.9	6.1	13.7	29.2
8			.7	5.2	12.2	27.8
9			.4	3.9	10.4	26.9
10			.3	3.6	9.6	26.4
11			.3	3.5	9.0	24.5
12			.3	3.3	8.7	24.0
13			.3	3.0	7.9	21.7
14			.2	2.9	7.8	21.6
15			.2	2.9	7.9	22.7
16			.2	3.0	8.1	23.7
17			.2	3.1	8.0	23.6
18			.3	3.0	7.8	22.8
19			.3	3.0	7.8	23.3
20			.3	3.0	7.8	22.6
21			.3	3.0	7.6	22.2
22			.3	3.0	7.5	22.0
23			.2	2.9	7.4	21.4
24			.2	2.8	7.1	20.4
25			.2	2.6	6.8	19.9
26			.2	2.5	6.7	19.6
27			.1	2.3	6.4	18.9
28			.1	2.3	6.3	18.5
29			.1	2.2	6.4	18.2
30			.1	2.3	6.7	19.2

L = SHORTAGE COST

TABLE 8

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

ON HAND PLUS ON ORDER
(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1	45.6	45.6	48.1	56.8	65.3	80.1
2	44.5	44.5	46.8	55.5	64.3	79.5
3	46.6	46.6	48.5	56.5	65.4	81.8
4	47.7	47.7	49.5	56.9	65.8	83.3
5	48.1	48.1	49.5	56.4	65.2	83.2
6	47.9	47.9	49.0	55.4	64.0	82.5
7	48.3	48.3	49.4	55.6	64.2	83.2
8	46.8	46.8	48.0	54.1	62.8	82.1
9	45.7	45.7	46.7	52.6	61.1	81.0
10	45.5	45.5	46.3	52.0	60.3	81.8
11	45.5	45.5	46.2	51.5	58.9	80.2
12	44.9	44.9	45.6	50.8	59.0	80.2
13	43.2	43.2	43.9	49.1	57.0	78.1
14	42.3	42.3	43.0	48.2	55.8	77.0
15	43.1	43.1	43.7	48.6	56.6	77.6
16	44.9	44.9	45.4	50.2	57.6	79.1
17	44.7	44.7	45.2	49.8	57.1	79.0
18	44.1	44.1	44.6	48.6	55.5	77.7
19	44.6	44.6	45.0	49.0	56.2	78.8
20	44.6	44.6	44.9	49.2	55.8	78.2
21	43.2	43.2	43.8	47.8	54.5	77.0
22	42.8	42.8	43.4	47.5	54.5	76.6
23	42.5	42.5	43.0	46.9	53.7	76.7
24	41.2	41.2	41.8	45.7	52.7	75.5
25	40.4	40.4	40.9	44.8	51.9	74.2
26	39.9	39.9	40.4	44.3	51.1	73.2
27	39.6	39.6	40.0	43.7	50.8	72.0
28	39.9	39.9	40.3	44.2	51.0	72.0
29	39.4	39.4	39.8	43.5	50.5	72.0
30	40.7	40.7	41.0	44.9	52.1	73.6

L = SHORTAGE COST

TABLE 9

Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

New Procurement vs. New Long Supply

Shortage Cost = $390

(Dollars in Millions)

Year	New Procurement	New Long Supply	Percent
1	75.95*	0.78	1.03
2	17.44	2.15	12.33
3	16.26	1.85	11.38
4	18.51	1.18	6.37
5	18.17	0.98	5.39
6	16.01	1.51	9.43
7	15.95	1.24	7.78
7.5	8.78	0.58	6.60

* This value includes procurements required to set up the inventory stockage level assets.

TABLE 10

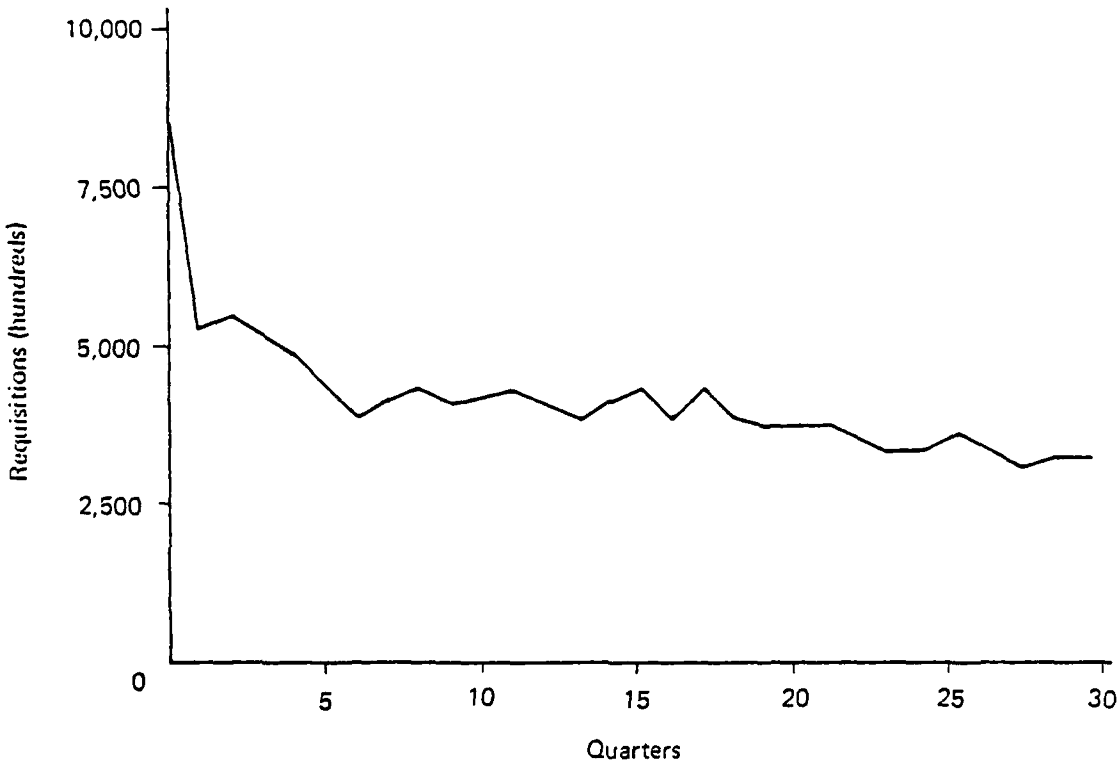
Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

MARGINAL ANALYSIS OF DATA AT END OF SIMULATION

(Dollars in Thousands)

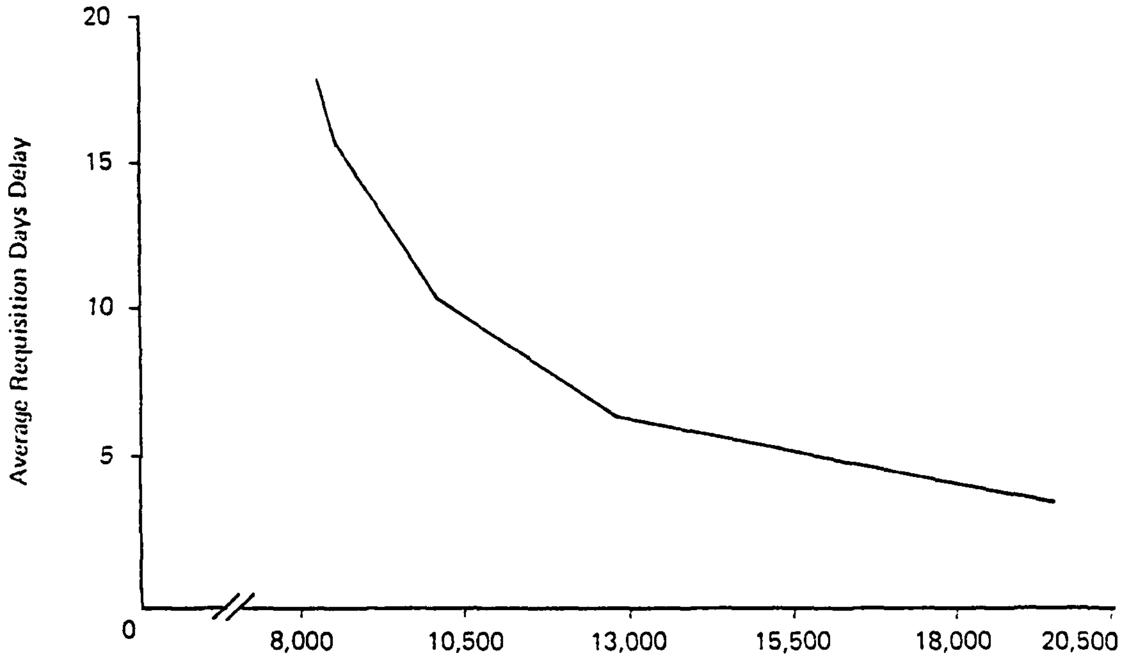
Change In Shortage Cost	Change In Dollar Value Of Procurements	Change In Dollar Value Of Long Supply	Percent Change In Requisition Fill Rate*	Percent Change In Average Days Delay
$0.10 to $100	381.5	301.0	1.18	12.12 (2.17 Days)
$100 to $555	4,045.4	1,619.8	4.65	34.56 (5.44 Days)
$555 to $1000	7,764.0	2,739.1	4.44	28.06 (3.92 Days)
$1000 to $100,000	22,139.4	7,010.5	3.09	46.24 (2.95 Days)

* Percent change is the percent improvement and is equal to the change in the measure divided by the measurement at the lower shortage cost.



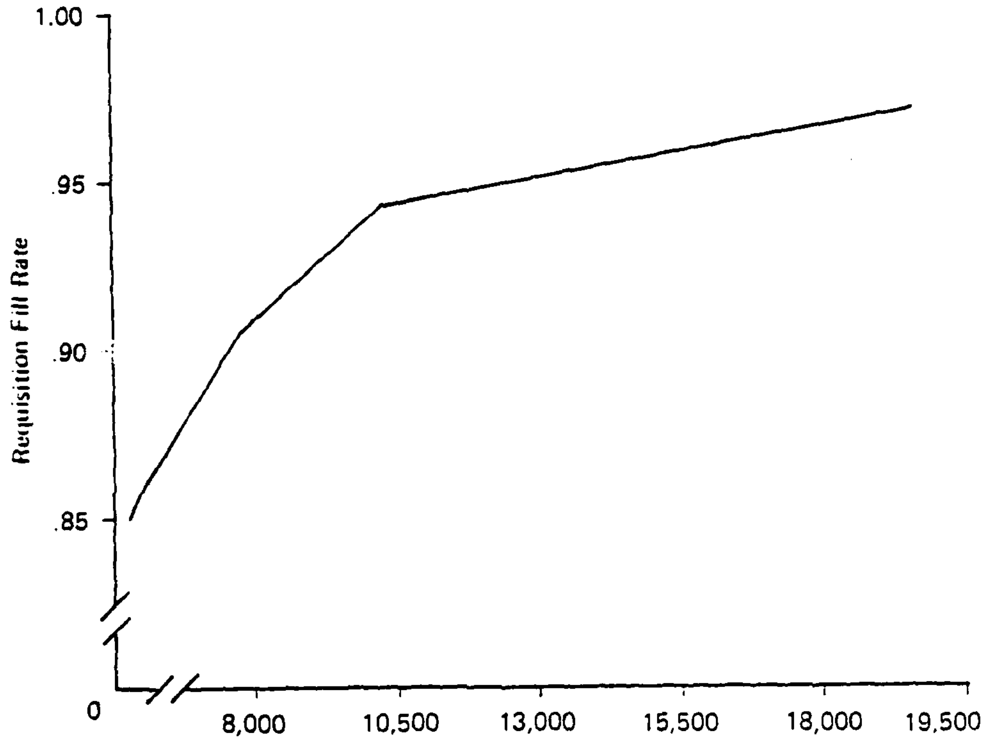
Appendix B, Graph 1
Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample
Requisition Trend During Simulation

Average Days Delay vs Long Supply (at End of Simulation)

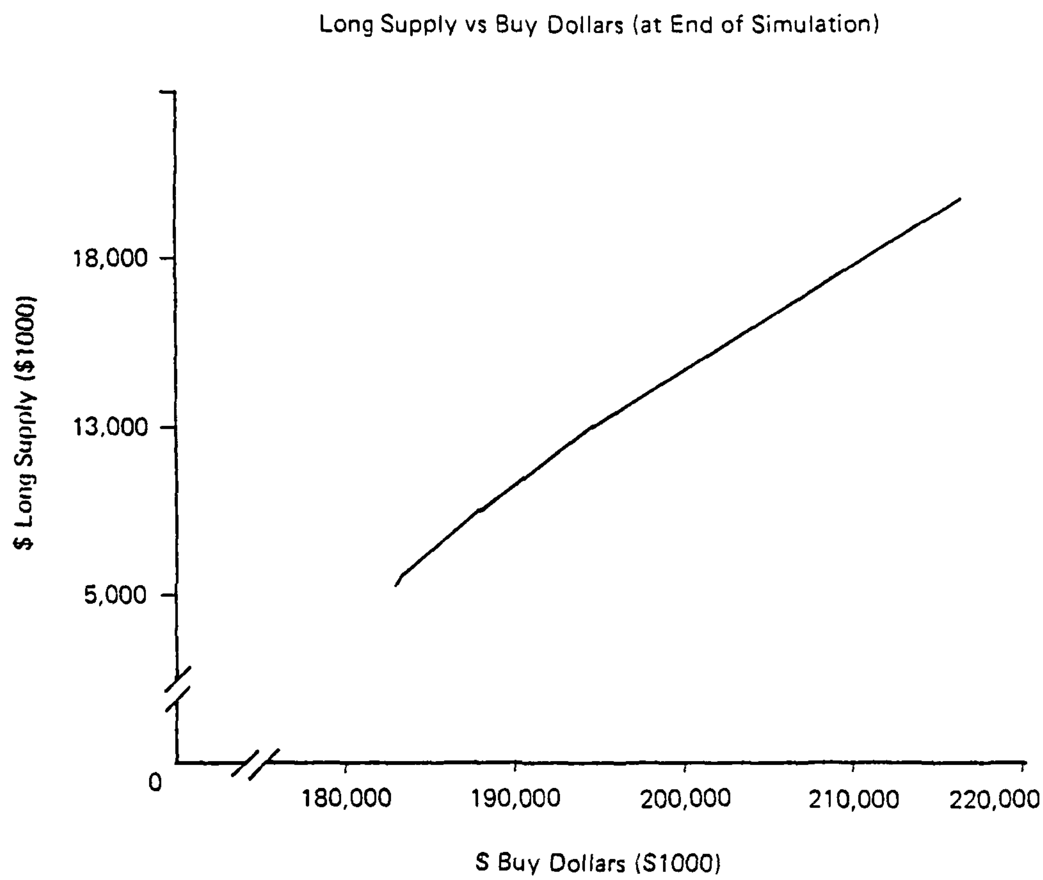


Appendix B, Graph 2
Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample

Requisition Fill Rate vs Long Supply (at End of Simulation)



Appendix B, Graph 3
Air Force Long Supply Simulation
Oklahoma City ALC High Demand Value Sample



Appendix B, Graph 4

Air Force Long Supply Simulation

Oklahoma City ALC High Demand Value Sample

APPENDIX C

TABLE 1

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.10	100	390	1,000	100,000
SIMULATION + 6 MONTHS						
REQUISITION FILL RATE	0.87	0.87	0.87	0.87	0.87	0.87
AVERAGE DAYS DELAY	7.84	7.84	7.76	7.61	7.61	7.61
$ CUM. BUYS	5.00	5.00	5.73	6.85	7.38	7.70
$ LONG SUPPLY (LS)	0.06	0.06	0.10	0.13	0.14	0.14
$ LS ÷ $ CUM. BUYS	0.012	0.012	0.018	0.020	0.019	0.018
$ SAFETY LEVEL	0	0	0.44	1.31	1.77	2.07
$ ON HAND + ON ORDER	4.60	4.60	5.32	6.44	6.97	7.29
SIMULATION + 12 MONTHS						
REQUISITION FILL RATE	0.82	0.82	0.83	0.84	0.84	0.84
AVERAGE DAYS DELAY	16.89	16.89	15.21	13.93	13.72	13.67
$ CUM. BUYS	6.16	6.16	6.79	7.90	8.50	8.89
$ LONG SUPPLY (LS)	0.21	0.21	0.34	0.46	0.51	0.53
$ LS ÷ $ CUM. BUYS	0.034	0.034	0.050	0.059	0.060	0.060
$ SAFETY LEVEL	0	0	0.36	1.16	1.65	1.96
$ ON HAND + ON ORDER	4.79	4.79	5.40	6.46	7.05	7.43
SIMULATION + 18 MONTHS						
REQUISITION FILL RATE	0.82	0.82	0.84	0.86	0.86	0.87
AVERAGE DAYS DELAY	19.13	19.13	16.26	13.94	13.36	13.19
$ CUM. BUYS	7.09	7.09	7.65	8.79	9.51	9.94
$ LONG SUPPLY (LS)	0.37	0.37	0.53	0.73	0.82	0.86
$ LS ÷ $ CUM. BUYS	0.052	0.052	0.070	0.083	0.086	0.086
$ SAFETY LEVEL	0	0	0.27	1.04	1.56	1.91
$ ON HAND + ON ORDER	4.79	4.79	5.28	6.35	7.04	7.46
SIMULATION + 24 MONTHS						
REQUISITION FILL RATE	0.83	0.83	0.86	0.88	0.88	0.89
AVERAGE DAYS DELAY	18.98	18.98	15.73	12.53	11.76	11.46
$ CUM. BUYS	7.97	7.97	8.45	9.67	10.38	10.94
$ LONG SUPPLY (LS)	0.51	0.51	0.72	0.97	1.08	1.15
$ LS ÷ $ CUM. BUYS	0.065	0.065	0.085	0.100	0.104	0.105
$ SAFETY LEVEL	0	0	0.18	0.92	1.48	1.89
$ ON HAND + ON ORDER	4.69	4.69	5.14	6.29	6.99	7.54
SIMULATION + 30 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.89	0.90	0.91
AVERAGE DAYS DELAY	17.56	17.56	14.27	10.97	10.13	9.81
$ CUM. BUYS	8.89	8.89	9.33	10.52	11.34	11.94
$ LONG SUPPLY (LS)	0.63	0.64	0.85	1.12	1.26	1.33
$ LS ÷ $ CUM. BUYS	0.071	0.071	0.091	0.106	0.111	0.112
$ SAFETY LEVEL	0	0	0.11	0.83	1.43	1.92
$ ON HAND + ON ORDER	4.67	4.67	5.10	6.23	7.03	7.62

TABLE 1

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.10	100	390	1,000	100,000
SIMULATION + 36 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.88	0.90	0.91	0.92
AVERAGE DAYS DELAY	16.56	16.56	13.34	10.01	8.98	8.61
$ CUM. BUYS	9.95	9.95	10.35	11.52	12.39	13.06
$ LONG SUPPLY (LS)	0.70	0.70	0.93	1.24	1.41	1.48
$ LS ÷ $ CUM. BUYS	0.071	0.071	0.090	0.108	0.114	0.114
$ SAFETY LEVEL	0	0	0.11	0.79	1.40	1.89
$ ON HAND + ON ORDER	4.83	4.83	5.23	6.33	7.14	7.78
SIMULATION + 42 MONTHS						
REQUISITION FILL RATE	0.86	0.86	0.88	0.91	0.92	0.92
AVERAGE DAYS DELAY	16.56	16.56	13.33	9.70	8.46	8.02
$ CUM. BUYS	10.75	10.75	11.13	12.31	13.18	13.91
$ LONG SUPPLY (LS)	0.76	0.76	0.98	1.34	1.56	1.69
$ LS ÷ $ CUM. BUYS	0.071	0.071	0.088	0.109	0.119	0.122
$ SAFETY LEVEL	0	0	0.09	0.70	1.27	1.79
$ ON HAND + ON ORDER	4.72	4.72	5.08	6.18	7.00	7.70
SIMULATION + 48 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.88	0.91	0.92	0.93
AVERAGE DAYS DELAY	17.12	17.12	13.80	9.60	8.22	7.70
$ CUM. BUYS	12.21	12.21	12.58	13.73	14.66	15.62
$ LONG SUPPLY (LS)	0.82	0.82	1.03	1.35	1.55	1.69
$ LS ÷ $ CUM. BUYS	0.067	0.067	0.082	0.098	0.106	0.108
$ SAFETY LEVEL	0	0	0.10	0.78	1.45	2.09
$ ON HAND + ON ORDER	5.17	5.17	5.51	6.56	7.43	8.36
SIMULATION + 54 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.92	0.93
AVERAGE DAYS DELAY	17.70	17.70	14.41	9.59	8.02	7.45
$ CUM. BUYS	13.36	13.36	13.67	14.88	15.90	16.91
$ LONG SUPPLY (LS)	0.94	0.94	1.15	1.49	1.74	1.93
$ LS ÷ $ CUM. BUYS	0.070	0.070	0.084	0.100	0.109	0.114
$ SAFETY LEVEL	0	0	0.09	0.76	1.46	2.07
$ ON HAND + ON ORDER	5.29	5.29	5.57	6.66	7.61	8.57
SIMULATION + 60 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.93	0.93
AVERAGE DAYS DELAY	18.07	18.07	14.82	9.59	7.88	7.25
$ CUM. BUYS	14.51	14.51	14.85	16.04	17.11	18.21
$ LONG SUPPLY (LS)	0.98	0.98	1.17	1.52	1.78	2.00
$ LS ÷ $ CUM. BUYS	0.068	0.068	0.079	0.095	0.104	0.110
$ SAFETY LEVEL	0	0	0.09	0.76	1.50	2.19
$ ON HAND + ON ORDER	5.35	5.35	5.66	6.77	7.77	8.85

TABLE 1 APPENDIX C

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.10	100	390	1,000	100,000
SIMULATION + 66 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.93	0.94
AVERAGE DAYS DELAY	17.95	17.95	14.81	9.42	7.62	6.96
$ CUM. BUYS	15.58	15.58	15.85	17.02	18.19	19.34
$ LONG SUPPLY (LS)	1.05	1.05	1.23	1.59	1.88	2.17
$ LS ÷ $ CUM. BUYS	0.067	0.067	0.078	0.093	0.104	0.112
$ SAFETY LEVEL	0	0	0.08	0.77	1.47	2.11
$ ON HAND + ON ORDER	5.31	5.31	5.56	6.66	7.76	8.88
SIMULATION + 72 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.93	0.94
AVERAGE DAYS DELAY	17.90	17.90	14.86	9.37	7.43	6.75
$ CUM. BUYS	16.50	16.50	16.80	17.96	19.10	20.23
$ LONG SUPPLY (LS)	1.14	1.14	1.34	1.73	2.10	2.45
$ LS ÷ $ CUM. BUYS	0.069	0.069	0.080	0.096	0.110	0.121
$ SAFETY LEVEL	0	0	0.08	0.69	1.33	1.96
$ ON HAND + ON ORDER	5.28	5.28	5.59	6.68	7.76	8.86
SIMULATION + 78 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.91	0.93	0.94
AVERAGE DAYS DELAY	17.72	17.72	14.84	9.35	7.31	6.60
$ CUM. BUYS	17.32	17.32	17.58	18.77	19.90	21.04
$ LONG SUPPLY (LS)	1.33	1.33	1.53	1.98	2.42	2.83
$ LS ÷ $ CUM. BUYS	0.077	0.077	0.087	0.105	0.122	0.135
$ SAFETY LEVEL	0	0	0.07	0.63	1.20	1.82
$ ON HAND + ON ORDER	5.24	5.24	5.51	6.64	7.71	8.82
SIMULATION + 84 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.92	0.93	0.94
AVERAGE DAYS DELAY	17.42	17.42	14.60	9.19	7.17	6.40
$ CUM. BUYS	18.03	18.03	18.35	19.47	20.61	21.79
$ LONG SUPPLY (LS)	1.57	1.57	1.78	2.28	2.74	3.18
$ LS ÷ $ CUM. BUYS	0.087	0.087	0.097	0.117	0.133	0.146
$ SAFETY LEVEL	0	0	0.07	0.59	1.13	1.69
$ ON HAND + ON ORDER	5.15	5.15	5.46	6.54	7.65	8.79
SIMULATION + 90 MONTHS						
REQUISITION FILL RATE	0.85	0.85	0.87	0.92	0.93	0.94
AVERAGE DAYS DELAY	17.16	17.16	14.43	9.05	6.97	6.17
$ CUM. BUYS	18.87	18.87	19.17	20.29	21.43	22.62
$ LONG SUPPLY (LS)	1.60	1.60	1.81	2.30	2.76	3.19
$ LS ÷ $ CUM. BUYS	0.085	0.085	0.094	0.113	0.129	0.141
$ SAFETY LEVEL	0	0	0.07	0.62	1.19	1.71
$ ON HAND + ON ORDER	5.15	5.15	5.44	6.50	7.58	8.73

TABLE 2

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

REQUISITION FILL RATE

CUMULATIVE

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1	0.93	0.93	0.93	0.93	0.93	0.93
2	0.87	0.87	0.87	0.87	0.87	0.87
3	0.82	0.82	0.83	0.83	0.83	0.83
4	0.82	0.82	0.83	0.84	0.84	0.84
5	0.82	0.82	0.83	0.85	0.85	0.85
6	0.82	0.82	0.84	0.86	0.86	0.87
7	0.83	0.83	0.85	0.87	0.88	0.88
8	0.83	0.83	0.86	0.88	0.88	0.89
9	0.84	0.84	0.86	0.89	0.89	0.90
10	0.85	0.85	0.87	0.89	0.90	0.91
11	0.85	0.85	0.87	0.90	0.91	0.91
12	0.85	0.85	0.88	0.90	0.91	0.92
13	0.86	0.86	0.88	0.90	0.91	0.92
14	0.86	0.86	0.88	0.91	0.92	0.92
15	0.86	0.86	0.88	0.91	0.92	0.92
16	0.85	0.85	0.88	0.91	0.92	0.93
17	0.85	0.85	0.88	0.91	0.92	0.93
18	0.85	0.85	0.87	0.91	0.92	0.93
19	0.85	0.85	0.87	0.91	0.92	0.93
20	0.85	0.85	0.87	0.91	0.93	0.93
21	0.85	0.85	0.87	0.91	0.93	0.93
22	0.85	0.85	0.87	0.91	0.93	0.94
23	0.85	0.85	0.87	0.91	0.93	0.94
24	0.85	0.85	0.87	0.91	0.93	0.94
25	0.85	0.85	0.87	0.91	0.93	0.94
26	0.85	0.85	0.87	0.91	0.93	0.94
27	0.85	0.85	0.87	0.91	0.93	0.94
28	0.85	0.85	0.87	0.92	0.93	0.94
29	0.85	0.85	0.87	0.92	0.93	0.94
30	0.85	0.85	0.87	0.92	0.93	0.94

L = SHORTAGE COST

TABLE 3

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

AVERAGE DAYS DELAY - - - REQUISITIONS

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
			CUMULATIVE			
1	2.50	2.50	2.50	2.50	2.50	2.50
2	7.84	7.84	7.76	7.61	7.61	7.61
3	13.66	13.66	13.04	12.55	12.57	12.46
4	16.89	16.89	15.21	13.93	13.72	13.67
5	18.15	18.15	15.96	14.19	13.84	13.71
6	19.13	19.13	16.26	13.94	13.36	13.19
7	19.41	19.41	16.21	13.27	12.54	12.29
8	18.98	18.98	15.73	12.53	11.76	11.46
9	18.24	18.24	14.99	11.70	10.90	10.59
10	17.56	17.56	14.27	10.97	10.13	9.81
11	16.96	16.96	13.69	10.35	9.44	9.10
12	16.56	16.56	13.34	10.01	8.98	8.61
13	16.48	16.48	13.31	9.83	8.68	8.30
14	16.56	16.56	13.33	9.70	8.46	8.02
15	16.78	16.78	13.54	9.63	8.31	7.84
16	17.12	17.12	13.80	9.60	8.22	7.70
17	17.40	17.40	14.08	9.55	8.10	7.55
18	17.70	17.70	14.41	9.59	8.02	7.45
19	17.97	17.97	14.73	9.62	7.99	7.39
20	18.07	18.07	14.82	9.59	7.88	7.25
21	18.04	18.04	14.84	9.52	7.75	7.11
22	17.95	17.95	14.81	9.42	7.62	6.96
23	17.87	17.87	14.76	9.35	7.50	6.83
24	17.90	17.90	14.86	9.37	7.43	6.75
25	17.87	17.87	14.90	9.38	7.37	6.68
26	17.72	17.72	14.84	9.35	7.31	6.60
27	17.60	17.60	14.75	9.30	7.26	6.52
28	17.42	17.42	14.60	9.19	7.17	6.40
29	17.25	17.25	14.48	9.10	7.06	6.27
30	17.16	17.16	14.43	9.05	6.97	6.17

L = SHORTAGE COST

TABLE 4

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

CUMULATIVE PROCUREMENT

(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
			CUMULATIVE			
1	4.5	4.5	5.3	6.3	6.8	7.2
2	5.0	5.0	5.7	6.8	7.4	7.7
3	5.6	5.6	6.3	7.3	8.0	8.3
4	6.2	6.2	6.8	8.0	8.5	8.9
5	6.6	6.6	7.2	8.4	9.0	9.4
6	7.1	7.1	7.6	8.8	9.5	9.9
7	7.5	7.5	8.1	9.3	10.0	10.0
8	8.0	8.0	8.5	9.7	10.4	10.9
9	8.5	8.5	8.9	10.1	10.9	11.5
10	8.9	8.9	9.3	10.5	11.3	11.9
11	9.4	9.4	9.8	11.0	11.8	12.5
12	9.9	9.9	10.4	11.5	12.4	13.1
13	10.3	10.3	10.7	11.8	12.8	13.5
14	10.7	10.7	11.1	12.3	13.2	13.9
15	11.6	11.6	12.0	13.1	14.1	14.9
16	12.2	12.2	12.6	13.7	14.7	15.6
17	12.8	12.8	13.1	14.3	15.3	16.2
18	13.4	13.4	13.7	14.9	15.9	16.9
19	13.9	13.9	14.3	15.5	16.5	17.6
20	14.5	14.5	14.8	16.0	17.1	18.2
21	15.0	15.0	15.3	16.5	17.6	18.7
22	15.6	15.6	15.8	17.0	18.2	19.3
23	16.1	16.1	16.4	17.5	18.7	19.8
24	16.5	16.5	16.8	18.0	19.1	20.2
25	16.8	16.8	17.2	18.4	19.5	20.6
26	17.3	17.3	17.6	18.8	20.0	21.0
27	17.7	17.7	18.0	19.1	20.3	21.4
28	18.0	18.0	18.3	19.5	20.6	21.8
29	18.3	18.3	18.6	19.8	20.9	22.1
30	18.9	18.9	19.2	20.3	21.4	22.6

L = SHORTAGE COST

TABLE 5

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

END OF PERIOD LONG SUPPLY
(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1	0	0	0	0	0	0
2	.1	.1	.1	.1	.1	.1
3	.1	.1	.2	.3	.3	.3
4	.2	.2	.3	.5	.5	.5
5	.3	.3	.4	.6	.6	.7
6	.4	.4	.5	.7	.8	.9
7	.4	.4	.6	.9	1.0	1.0
8	.5	.5	.7	1.0	1.1	1.2
9	.6	.6	.8	1.0	1.2	1.2
10	.6	.6	.8	1.1	1.3	1.3
11	.7	.7	.9	1.2	1.3	1.4
12	.7	.7	.9	1.2	1.4	1.5
13	.7	.7	1.0	1.3	1.5	1.6
14	.8	.8	1.0	1.3	1.6	1.7
15	.8	.8	1.0	1.3	1.5	1.7
16	.8	.8	1.0	1.3	1.5	1.7
17	.9	.9	1.1	1.4	1.6	1.8
18	.9	.9	1.1	1.5	1.7	1.9
19	1.0	1.0	1.2	1.6	1.8	2.0
20	1.0	1.0	1.2	1.5	1.8	2.0
21	1.0	1.0	1.2	1.5	1.8	2.1
22	1.0	1.0	1.2	1.6	1.9	2.2
23	1.1	1.1	1.3	1.7	2.0	2.3
24	1.1	1.1	1.3	1.7	2.1	2.4
25	1.2	1.2	1.4	1.8	2.2	2.6
26	1.3	1.3	.15	2.0	2.4	2.8
27	1.4	1.4	1.6	2.1	2.6	3.0
28	1.6	1.6	1.8	2.3	2.7	3.2
29	1.6	1.6	1.8	2.3	2.7	3.2
30	1.6	1.6	1.8	2.3	2.8	3.2

L = SHORTAGE COST

TABLE 6

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

RATIO OF EOP LONG SUPPLY $ TO CUM BUY $

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1	0	0	0	0	0	0
2	0.012	0.012	0.018	0.020	0.019	0.018
3	0.021	0.021	0.035	0.039	0.039	0.038
4	0.034	0.034	0.050	0.059	0.060	0.060
5	0.041	0.041	0.058	0.070	0.072	0.072
6	0.052	0.052	0.070	0.083	0.086	0.086
7	0.058	0.058	0.077	0.093	0.096	0.097
8	0.065	0.065	0.085	0.100	0.104	0.105
9	0.066	0.066	0.088	0.103	0.108	0.108
10	0.071	0.071	0.091	0.106	0.111	0.112
11	0.071	0.071	0.090	0.106	0.112	0.113
12	0.071	0.071	0.090	0.108	0.114	0.114
13	0.071	0.071	0.090	0.111	0.120	0.121
14	0.071	0.071	0.088	0.109	0.119	0.122
15	0.067	0.067	0.083	0.102	0.110	0.112
16	0.067	0.067	0.082	0.098	0.106	0.108
17	0.068	0.068	0.082	0.098	0.107	0.112
18	0.070	0.070	0.084	0.100	0.109	0.114
19	0.072	0.072	0.084	0.101	0.109	0.116
20	0.068	0.068	0.079	0.095	0.104	0.110
21	0.066	0.066	0.077	0.093	0.103	0.110
22	0.067	0.067	0.078	0.093	0.104	0.112
23	0.069	0.069	0.080	0.094	0.107	0.116
24	0.069	0.069	0.080	0.096	0.110	0.121
25	0.074	0.074	0.084	0.101	0.115	0.127
26	0.077	0.077	0.087	0.105	0.122	0.135
27	0.081	0.081	0.091	0.111	0.128	0.141
28	0.087	0.087	0.097	0.117	0.133	0.146
29	0.085	0.085	0.095	0.115	0.130	0.144
30	0.085	0.085	0.094	0.113	0.129	0.141

L = SHORTAGE COST

TABLE 7

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

SAFETY LEVEL REQUIREMENT BY QUARTER
(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1			.5	1.5	1.9	2.2
2			.4	1.3	1.8	2.1
3			.4	1.2	1.7	2.0
4			.4	1.2	1.7	2.0
5			.3	1.1	1.6	1.9
6			.3	1.0	1.6	1.9
7			.2	1.0	1.6	1.9
8			.2	.9	1.5	1.9
9			.1	.8	1.4	1.9
10			.1	.8	1.4	1.9
11			.1	.8	1.4	1.9
12			.1	.8	1.4	1.9
13			.1	.7	1.3	1.8
14			.1	.7	1.3	1.8
15			.1	.8	1.4	2.0
16			.1	.8	1.5	2.1
17			.1	.8	1.5	2.1
18			.1	.8	1.5	2.1
19			.1	.8	1.5	2.1
20			.1	.8	1.5	2.2
21			.1	.8	1.5	2.2
22			.1	.8	1.5	2.1
23			.1	.7	1.4	2.1
24			.1	.7	1.3	1.9
25			.1	.7	1.3	1.9
26			.1	.6	1.2	1.8
27			.1	.6	1.1	1.7
28			.1	.6	1.1	1.7
29			.1	.6	1.1	1.7
30			.1	.6	1.2	1.7

L = SHORTAGE COST

TABLE 8

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

ON HAND PLUS ON ORDER
(Millions of Dollars)

QUARTER	SL=0	L=.1	L=100	L=390	L=1,000	L=100,000
1	4.5	4.5	5.3	6.3	6.8	7.2
2	4.6	4.6	5.3	6.4	7.0	7.3
3	4.7	4.7	5.4	6.5	7.1	7.4
4	4.8	4.8	5.4	6.5	7.1	7.4
5	4.7	4.7	5.3	6.4	7.0	7.3
6	4.8	4.8	5.3	6.3	7.0	7.5
7	4.7	4.7	5.2	6.3	7.0	7.5
8	4.7	4.7	5.1	6.3	7.0	7.5
9	4.7	4.7	5.2	6.3	7.1	7.7
10	4.7	4.7	5.1	6.2	7.0	7.6
11	4.7	4.7	5.1	6.2	7.0	7.7
12	4.8	4.8	5.2	6.3	7.1	7.8
13	4.7	4.7	5.1	6.2	7.1	7.8
14	4.7	4.7	5.1	6.2	7.0	7.7
15	5.1	5.1	5.5	6.5	7.4	8.2
16	5.2	5.2	5.5	6.6	7.4	8.4
17	5.2	5.2	5.5	6.6	7.6	8.4
18	5.3	5.3	5.6	6.7	7.6	8.6
19	5.3	5.3	5.6	6.7	7.7	8.7
20	5.3	5.3	5.7	6.8	7.8	8.9
21	5.3	5.3	5.6	6.7	7.8	8.9
22	5.3	5.3	5.6	6.7	7.8	8.9
23	5.3	5.3	5.6	6.7	7.8	8.9
24	5.3	5.3	5.6	6.7	7.8	8.9
25	5.2	5.2	5.6	6.7	7.7	8.9
26	5.2	5.2	5.5	6.6	7.7	8.8
27	5.2	5.2	5.5	6.6	7.7	8.8
28	5.1	5.1	5.5	6.5	7.6	8.8
29	5.0	5.0	5.3	6.4	7.5	8.6
30	5.1	5.1	5.4	6.5	7.6	8.7

L = SHORTAGE COST

TABLE 9

Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

New Procurement vs. New Long Supply

Shortage Cost = $390

(Dollars in Millions)

Year	New Procurement	New Long Supply	Percent
1	7.90*	0.46	5.82
2	1.77	0.51	28.81
3	1.75	0.27	14.59
4	2.21	0.11	4.98
5	2.31	0.17	7.36
6	1.92	0.21	10.94
7	1.51	0.55	36.42
7.5	0.82	0.02	2.44

* This value includes procurements required to set up the inventory stockage level assets.

TABLE 10

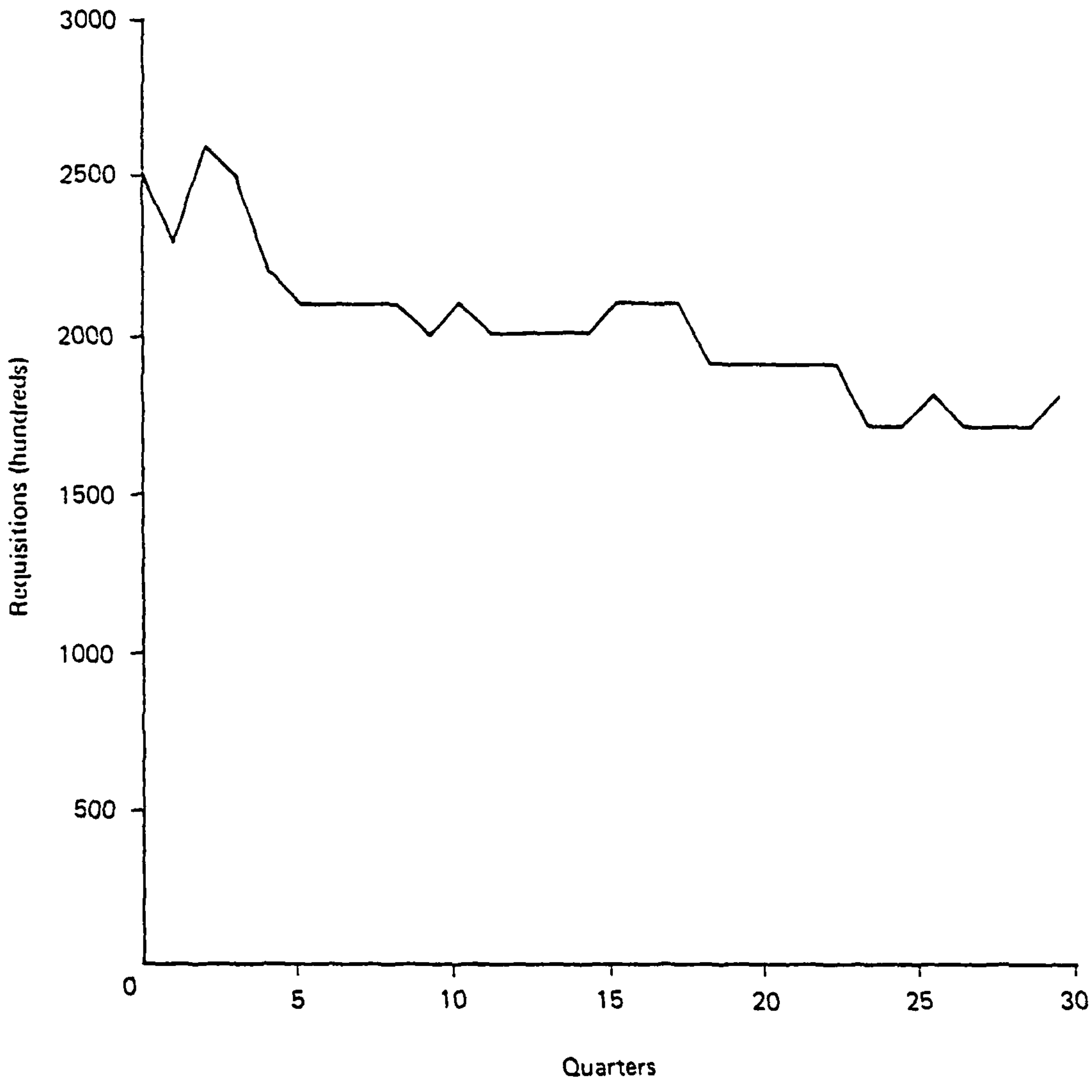
Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

MARGINAL ANALYSIS OF DATA AT END OF SIMULATION

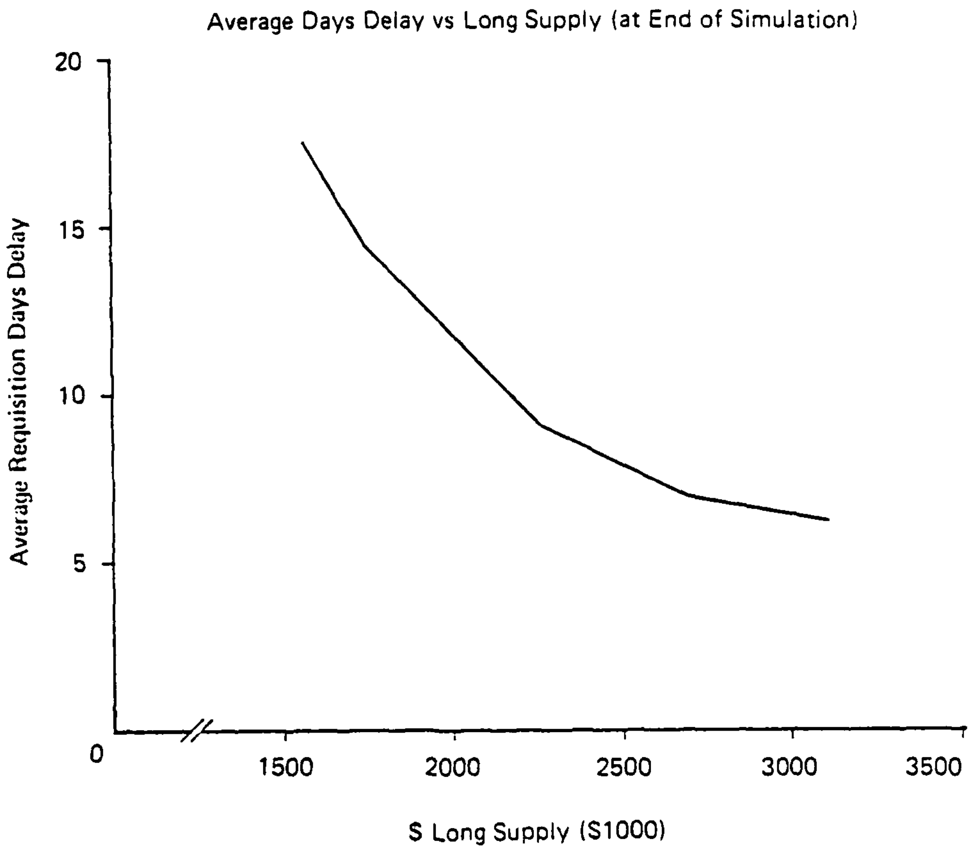
(Dollars in Thousands)

Change In Shortage Cost	Change In Dollar Value Of Procurements	Change In Dollar Value Of Long Supply	Percent Change In Requisition Fill Rate*	Percent Change In Average Days Delay*
$0.10 to $100	300.4	214.1	2.35	15.91 (2.73 Days)
$100 to $555	1,122.6	492.0	5.75	37.28 (5.38 Days)
$555 to $1000	1,145.6	463.5	1.09	22.98 (2.08 Days)
$1000 to $100,000	1,184.6	425.9	1.08	11.48 (0.80 Days)

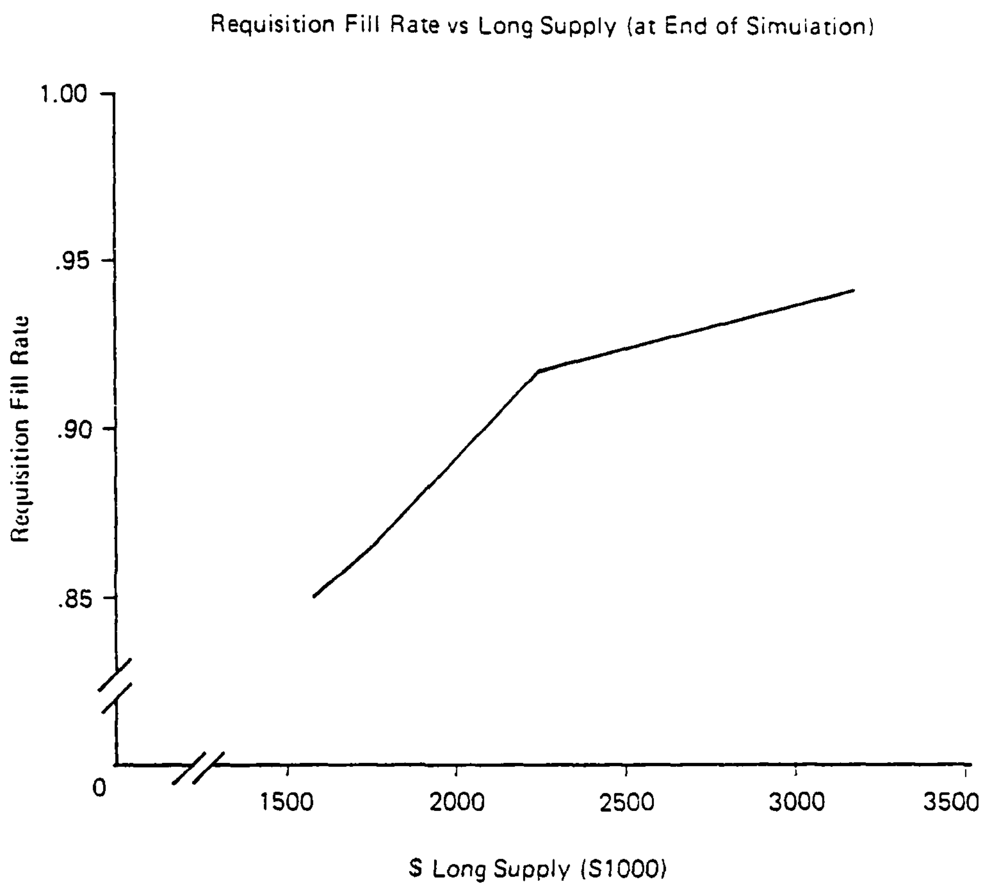
* Percent change is the percent improvement and is equal to the change in the measure divided by the measurement at the lower shortage cost.



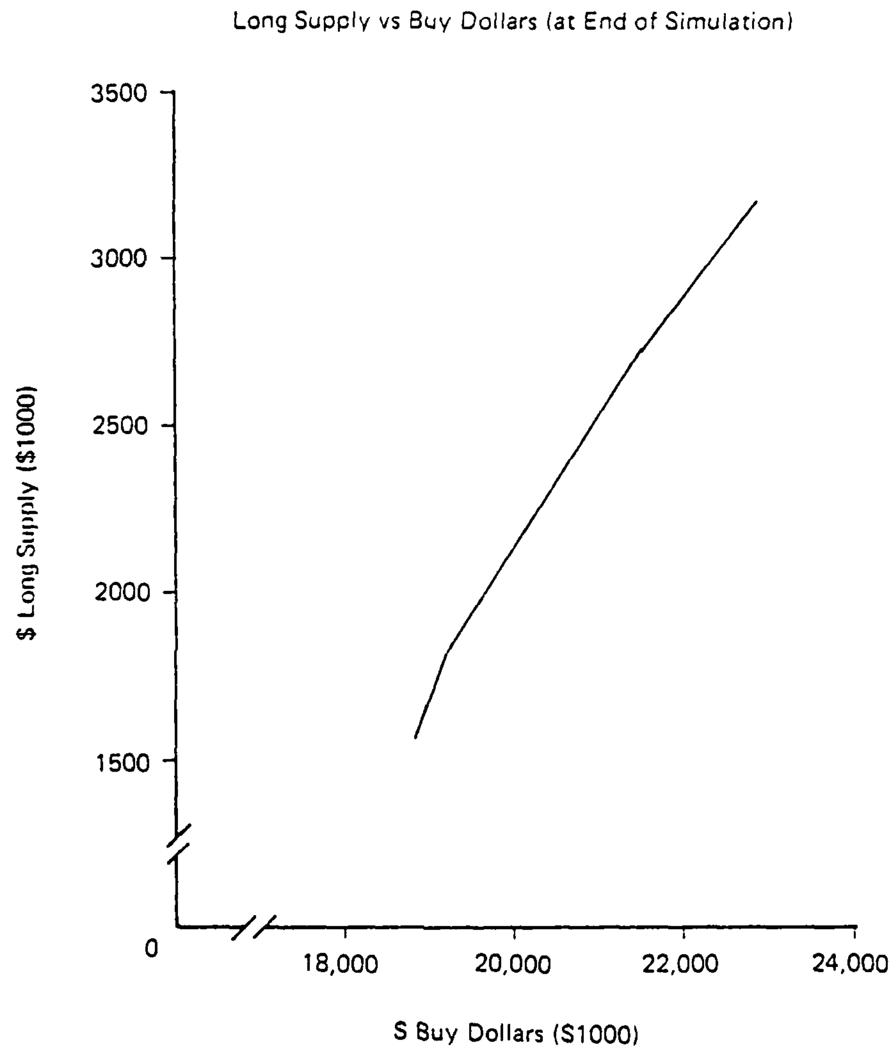
Appendix C, Graph 1
Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample
Requisition Trend During Simulation



Appendix C, Graph 2
Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample



Appendix C, Graph 3
Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample



Appendix C, Graph 4
Air Force Long Supply Simulation
Oklahoma City ALC Low Demand Value Sample

APPENDIX D

TABLE 1

Air Forc. Long Supply Simulation
Sacramento Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	100	555	1,000	100,000
SIMULATION + 6 MONTHS					
REQUISITION FILL RATE	0.85	0.85	0.86	0.86	0.86
AVERAGE DAYS DELAY	7.91	7.86	7.75	7.75	7.75
$ CUM. BUYS	2.68	2.81	3.23	3.37	3.67
$ LONG SUPPLY (LS)	0.03	0.04	0.04	0.05	0.05
$ LS ÷ $ CUM. BUYS	0.012	0.013	0.014	0.014	0.014
$ SAFETY LEVEL	0	0.12	0.50	0.63	0.89
$ ON HAND + ON ORDER	2.56	2.70	3.12	3.26	3.55
SIMULATION + 12 MONTHS					
REQUISITION FILL RATE	0.88	0.88	0.89	0.89	0.89
AVERAGE DAYS DELAY	8.74	8.59	8.04	8.00	7.97
$ CUM. BUYS	2.92	3.04	3.49	3.64	3.97
$ LONG SUPPLY (LS)	0.11	0.12	0.15	0.16	0.19
$ LS ÷ $ CUM. BUYS	0.038	0.040	0.055	0.046	0.047
$ SAFETY LEVEL	0	0.10	0.43	0.55	0.80
$ ON HAND + ON ORDER	2.37	2.48	2.93	3.08	3.41
SIMULATION + 18 MONTHS					
REQUISITION FILL RATE	.090	0.90	0.91	0.91	0.91
AVERAGE DAYS DELAY	8.02	7.49	6.55	6.41	6.30
$ CUM. BUYS	3.23	3.35	3.78	3.93	4.26
$ LONG SUPPLY (LS)	0.28	0.30	0.39	0.42	0.46
$ LS ÷ $ CUM. BUYS	0.086	0.091	0.103	0.106	0.109
$ SAFETY LEVEL	0	0.07	0.38	0.48	0.71
$ ON HAND + ON ORDER	2.34	2.45	2.86	3.02	3.34
SIMULATION + 24 MONTHS					
REQUISITION FILL RATE	0.90	0.91	0.92	0.92	0.93
AVERAGE DAYS DELAY	8.26	7.50	6.01	5.82	5.62
$ CUM. BUYS	3.49	3.60	4.04	4.20	4.56
$ LONG SUPPLY (LS)	0.43	0.47	0.59	0.63	0.70
$ LS ÷ $ CUM. BUYS	0.124	0.130	0.147	0.150	0.153
$ SAFETY LEVEL	0	0.05	0.31	0.43	0.65
$ ON HAND + ON ORDER	2.30	2.40	2.83	2.98	3.34
SIMULATION + 30 MONTHS					
REQUISITION FILL RATE	0.91	0.92	0.92	0.92	0.94
AVERAGE DAYS DELAY	7.94	7.11	5.49	5.23	4.97
$ CUM. BUYS	3.74	3.86	4.26	4.42	4.79
$ LONG SUPPLY (LS)	0.52	0.56	0.70	0.73	0.81
$ LS ÷ $ CUM. BUYS	0.139	0.145	0.164	0.166	0.170
$ SAFETY LEVEL	0	0.03	0.26	0.36	0.59
$ ON HAND + ON ORDER	2.21	2.33	2.73	2.88	3.24

TABLE 1

Air Force Long Supply Simulation
Sacramento Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	100	555	1,000	100,000
SIMULATION + 36 MONTHS					
REQUISITION FILL RATE	0.91	0.92	0.94	0.94	0.94
AVERAGE DAYS DELAY	7.79	6.89	5.14	4.84	4.52
$ CUM. BUYS	4.02	4.12	4.53	4.71	5.09
$ LONG SUPPLY (LS)	0.57	0.61	0.76	0.81	0.91
$ LS ÷ $ CUM. BUYS	0.142	0.149	0.167	0.171	0.179
$ SAFETY LEVEL	0	0.03	0.23	0.32	0.53
$ ON HAND + ON ORDER	2.19	2.78	2.68	2.86	3.22
SIMULATION + 42 MONTHS					
REQUISITION FILL RATE	0.91	0.92	0.94	0.94	0.95
AVERAGE DAYS DELAY	7.81	6.88	5.15	4.80	4.46
$ CUM. BUYS	4.41	4.50	4.91	5.08	5.50
$ LONG SUPPLY (LS)	0.62	0.68	0.84	0.90	1.01
$ LS ÷ $ CUM. BUYS	0.140	0.150	0.171	0.177	0.183
$ SAFETY LEVEL	0	0.02	0.18	0.26	0.51
$ ON HAND + ON ORDER	2.24	2.34	2.75	2.90	3.31
SIMULATION + 48 MONTHS					
REQUISITION FILL RATE	0.91	0.92	0.94	0.94	0.95
AVERAGE DAYS DELAY	8.11	7.19	5.45	5.00	4.66
$ CUM. BUYS	5.27	5.37	5.98	6.18	6.76
$ LONG SUPPLY (LS)	0.66	0.72	0.89	0.94	1.06
$ LS ÷ $ CUM. BUYS	0.125	0.134	0.149	0.153	0.157
$ SAFETY LEVEL	0	0.02	0.40	0.54	0.81
$ ON HAND + ON ORDER	2.86	2.95	3.55	3.75	4.31
SIMULATION + 54 MONTHS					
REQUISITION FILL RATE	0.92	0.93	0.94	0.95	0.95
AVERAGE DAYS DELAY	8.01	7.12	5.34	4.87	4.51
$ CUM. BUYS	5.51	5.60	6.17	6.39	6.99
$ LONG SUPPLY (LS)	0.84	0.90	1.14	1.21	1.40
$ LS ÷ $ CUM. BUYS	0.152	0.161	0.184	0.189	0.200
$ SAFETY LEVEL	0	0.02	0.31	0.43	0.72
$ ON HAND + ON ORDER	2.84	2.93	3.50	3.71	4.30
SIMULATION + 60 MONTHS					
REQUISITION FILL RATE	0.92	0.93	0.94	0.945	0.95
AVERAGE DAYS DELAY	7.71	6.87	5.08	4.62	4.25
$ CUM. BUYS	5.68	5.77	6.35	6.56	7.13
$ LONG SUPPLY (LS)	0.97	1.04	1.31	1.39	1.62
$ LS ÷ $ CUM. BUYS	0.171	0.180	0.205	0.211	0.227
$ SAFETY LEVEL	0	0.02	0.29	0.40	0.65
$ ON HAND + ON ORDER	2.72	2.80	3.38	3.59	4.15

TABLE 1 APPENDIX D

Air Force Long Supply Simulation
Sacramento Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	100	555	1,000	100,000
SIMULATION + 66 MONTHS					
REQUISITION FILL RATE	0.92	0.93	0.95	0.95	0.95
AVERAGE DAYS DELAY	7.80	6.93	4.98	4.53	4.14
\$ CUM. BUYS	5.81	5.90	6.49	6.68	7.24
\$ LONG SUPPLY (LS)	1.50	1.57	1.98	2.11	2.49
\$ LS ÷ \$ CUM. BUYS	0.259	0.267	0.305	0.315	0.343
\$ SAFETY LEVEL	0	0.14	0.13	0.20	0.35
\$ ON HAND + ON ORDER	2.67	2.76	3.34	3.53	4.09
SIMULATION + 72 MONTHS					
REQUISITION FILL RATE	0.92	0.93	0.95	0.95	0.96
AVERAGE DAYS DELAY	7.61	6.73	4.75	4.33	3.94
\$ CUM. BUYS	5.91	5.99	6.57	6.76	7.31
\$ LONG SUPPLY (LS)	1.62	1.69	2.11	2.25	2.65
\$ LS ÷ \$ CUM. BUYS	0.274	0.282	0.321	0.333	0.362
\$ SAFETY LEVEL	0	0.01	0.09	0.14	0.27
\$ ON HAND + ON ORDER	2.57	2.64	3.21	3.40	3.95
SIMULATION + 78 MONTHS					
REQUISITION FILL RATE	0.92	0.93	0.95	0.95	0.96
AVERAGE DAYS DELAY	7.69	6.77	4.69	4.26	3.86
\$ CUM. BUYS	6.04	6.11	6.69	6.89	7.44
\$ LONG SUPPLY (LS)	1.61	1.68	2.11	2.25	2.66
\$ LS ÷ \$ CUM. BUYS	0.266	0.274	0.315	0.327	0.358
\$ SAFETY LEVEL	0	0.01	0.08	0.13	0.24
\$ ON HAND + ON ORDER	2.51	2.58	3.15	3.35	3.89
SIMULATION + 84 MONTHS					
REQUISITION FILL RATE	0.92	0.93	0.95	0.95	0.96
AVERAGE DAYS DELAY	7.78	6.91	4.71	4.23	3.81
\$ CUM. BUYS	6.14	6.22	6.77	6.98	7.52
\$ LONG SUPPLY (LS)	1.58	1.65	2.08	2.22	2.62
\$ LS ÷ \$ CUM. BUYS	0.258	0.266	0.308	0.318	0.348
\$ SAFETY LEVEL	0	0.01	0.08	0.12	0.22
\$ ON HAND + ON ORDER	2.42	2.50	3.05	3.24	3.79
SIMULATION + 90 MONTHS					
REQUISITION FILL RATE	0.92	0.93	0.95	0.95	0.96
AVERAGE DAYS DELAY	7.90	7.08	4.82	4.27	3.79
\$ CUM. BUYS	6.29	6.36	6.94	7.14	7.65
\$ LONG SUPPLY (LS)	1.57	1.64	2.06	2.19	2.58
\$ LS ÷ \$ CUM. BUYS	0.250	0.258	0.297	0.307	0.336
\$ SAFETY LEVEL	0	0.01	0.08	0.13	0.24
\$ ON HAND + ON ORDER	2.41	2.48	3.05	3.25	3.76

TABLE 2

Air Force Long Supply Simulation
Sacramento Sample

REQUISITION FILL RATE

QUARTER	SL=0	L=100	L=555	L=1,000	L=100,000
			CUMULATIVE		
1	0.89	0.89	0.89	0.89	0.89
2	0.85	0.85	0.86	0.86	0.86
3	0.86	0.86	0.86	0.86	0.86
4	0.88	0.88	0.89	0.89	0.89
5	0.89	0.90	0.90	0.90	0.90
6	0.90	0.90	0.91	0.91	0.91
7	0.90	0.91	0.92	0.92	0.92
8	0.90	0.91	0.92	0.92	0.93
9	0.91	0.92	0.93	0.93	0.94
10	0.91	0.92	0.93	0.93	0.94
11	0.91	0.92	0.94	0.94	0.94
12	0.91	0.92	0.94	0.94	0.94
13	0.91	0.92	0.04	0.94	0.94
14	0.91	0.92	0.94	0.94	0.95
15	0.91	0.92	0.94	0.94	0.95
16	0.91	0.92	0.94	0.94	0.95
17	0.92	0.92	0.94	0.94	0.95
18	0.92	0.93	0.94	0.95	0.95
19	0.92	0.93	0.94	0.95	0.95
20	0.92	0.93	0.94	0.95	0.95
21	0.92	0.93	0.94	0.95	0.95
22	0.92	0.93	0.95	0.95	0.96
23	0.92	0.93	0.95	0.95	0.96
24	0.92	0.93	0.95	0.95	0.96
25	0.92	0.93	0.95	0.95	0.96
26	0.92	0.93	0.95	0.95	0.96
27	0.92	0.93	0.95	0.95	0.96
28	0.92	0.93	0.95	0.95	0.96
29	0.92	0.93	0.95	0.95	0.96
30	0.92	0.93	0.95	0.95	0.96

L = SHORTAGE COST

TABLE 3

Air Force Long Supply Simulation
Sacramento Sample

AVERAGE DAYS DELAY - - - REQUISITIONS

CUMULATIVE

QUARTER	SL=0	L=100	L=555	L=1,000	L=100,000
1	1.90	1.90	1.90	1.90	1.90
2	7.91	7.86	7.75	7.75	7.75
3	9.85	9.78	9.45	9.45	9.43
4	8.74	8.59	8.04	8.00	7.97
5	8.16	7.88	7.16	7.07	7.00
6	8.02	7.49	6.55	6.41	6.30
7	8.19	7.49	6.22	6.02	5.90
8	8.26	7.50	6.01	5.82	5.62
9	8.09	7.31	5.72	5.50	5.25
10	7.94	7.11	5.49	5.23	4.90
11	7.85	6.97	5.28	4.99	4.72
12	7.79	6.89	5.14	4.84	4.52
13	7.79	6.85	5.09	4.78	4.44
14	7.81	6.88	5.15	4.80	4.46
15	7.93	7.00	5.30	4.91	4.56
16	8.11	7.19	5.45	5.00	4.66
17	8.13	7.23	5.44	4.98	4.62
18	8.01	7.12	5.34	4.87	4.51
19	7.85	6.97	5.20	4.73	4.37
20	7.77	6.87	5.08	4.62	4.25
21	7.83	6.95	5.04	4.59	4.20
22	7.80	6.93	4.98	4.53	4.14
23	7.70	6.83	4.86	4.42	4.03
24	7.61	6.73	4.75	4.33	3.94
25	7.61	6.74	4.69	4.27	3.88
26	7.69	6.77	4.69	4.26	3.86
27	7.77	6.88	4.71	4.25	3.84
28	7.78	6.91	4.71	4.23	3.81
29	7.78	6.93	4.73	4.21	3.77
30	7.90	7.08	4.82	4.27	3.79

L = SHORTAGE COST

TABLE 4

Air Force Long Supply Simulation
Sacramento Sample

CUMULATIVE PROCUREMENT
(Millions of Dollars)

QUARTER	SL=0	L=100	L=555	L=1,000	L=100,000
			CUMULATIVE		
1	2.5	2.7	3.1	3.2	3.5
2	2.7	2.8	3.2	3.4	3.7
3	2.8	2.9	3.3	3.5	3.8
4	2.9	3.0	3.5	3.6	4.0
5	3.0	3.2	3.6	3.7	4.1
6	3.2	3.4	3.8	3.9	4.3
7	3.4	3.5	3.9	4.1	4.4
8	3.4	3.6	4.0	4.2	4.6
9	3.6	3.7	4.1	4.3	4.7
10	3.7	3.9	4.3	4.4	4.8
11	3.9	4.0	4.4	4.6	4.9
12	4.0	4.1	4.5	4.7	5.1
13	4.2	4.3	4.7	4.9	5.3
14	4.4	4.5	4.9	5.1	5.5
15	5.1	5.2	5.8	6.0	6.6
16	5.3	5.4	6.0	6.2	6.8
17	5.4	5.5	6.1	6.3	6.9
18	5.5	5.6	6.2	6.4	7.0
19	5.6	5.7	6.3	6.5	7.0
20	5.7	5.8	6.4	6.6	7.1
21	5.8	5.8	6.4	6.6	7.2
22	5.8	5.9	6.5	6.7	7.2
23	5.9	5.9	6.5	6.7	7.3
24	5.9	6.0	6.6	6.9	7.4
25	6.0	6.1	6.6	6.9	7.4
26	6.0	6.1	6.7	6.9	7.5
27	6.1	6.2	6.7	6.9	7.5
28	6.1	6.2	6.8	7.0	7.5
29	6.2	6.3	6.9	7.0	7.6
30	6.3	6.4	6.9	7.1	7.7

L = SHORTAGE COST

TABLE 5

Air Force Long Supply Simulation
Sacramento Sample

END OF PERIOD LONG SUPPLY
(Millions of Dollars)

QUARTER	SL=0	L=100	L=555	L=1,000	L=100,000
1	0	0	0	0	0
2	0	0	0	0	.1
3	.1	.1	.1	.1	.1
4	.1	.1	.2	.2	.2
5	.2	.2	.3	.3	.4
6	.3	.3	.4	.4	.5
7	.4	.4	.5	.5	.6
8	.4	.5	.6	.6	.7
9	.5	.5	.7	.7	.8
10	.5	.6	.7	.7	.8
11	.5	.6	.7	.8	.8
12	.6	.6	.8	.8	.9
13	.6	.7	.8	.9	1.0
14	.6	.7	.8	.9	1.0
15	.6	.7	.9	.9	1.0
16	.7	.7	.9	.9	1.1
17	.8	.8	1.0	1.1	1.2
18	.8	.9	1.1	1.2	1.4
19	.9	.9	1.1	1.2	1.4
20	1.0	1.0	1.3	1.4	1.6
21	1.3	1.4	1.8	1.9	2.2
22	1.5	1.6	2.0	2.1	2.5
23	1.6	1.6	2.1	2.2	2.6
24	1.6	1.7	2.1	2.3	2.6
25	1.6	1.7	2.1	2.3	2.7
26	1.6	1.7	2.1	2.3	2.7
27	1.6	1.7	2.1	2.2	2.6
28	1.6	1.7	2.1	2.2	2.6
29	1.6	1.6	2.1	2.2	2.6
30	1.6	1.6	2.1	2.2	2.6

L = SHORTAGE COST

TABLE 6

Air Force Long Supply Simulation
Sacramento Sample

RATIO OF EOP LONG SUPPLY $ TO CUM BUY $

QUARTER	SL=0	L=100	L=555	L=1,000	L=100,000
1	0	0	0	0	0
2	0.012	0.013	0.014	0.014	0.014
3	0.027	0.029	0.030	0.030	0.030
4	0.038	0.040	0.044	0.046	0.047
5	0.069	0.073	0.083	0.087	0.090
6	0.086	0.091	0.103	0.106	0.109
7	0.107	0.112	0.127	0.130	0.133
8	0.124	0.130	0.147	0.150	0.153
9	0.139	0.147	0.165	0.168	0.170
10	0.139	0.145	0.164	0.166	0.170
11	0.138	0.144	0.163	0.167	0.172
12	0.142	0.149	0.167	0.171	0.179
13	0.147	0.154	0.175	0.181	0.191
14	0.140	0.150	0.171	0.177	0.183
15	0.125	0.134	0.148	0.152	0.155
16	0.125	0.134	0.149	0.153	0.157
17	0.138	0.147	0.163	0.168	0.175
18	0.152	0.161	0.184	0.189	0.200
19	0.156	0.165	0.184	0.189	0.202
20	0.171	0.180	0.205	0.211	0.227
21	0.230	0.239	0.277	0.284	0.302
22	0.259	0.267	0.305	0.315	0.343
23	0.269	0.277	0.317	0.328	0.356
24	0.274	0.282	0.321	0.333	0.362
25	0.269	0.277	0.319	0.329	0.360
26	0.266	0.274	0.315	0.327	0.358
27	0.261	0.269	0.311	0.322	0.352
28	0.258	0.266	0.308	0.318	0.348
29	0.253	0.261	0.302	0.313	0.342
30	0.250	0.258	0.297	0.307	0.336

L = SHORTAGE COST

TABLE 7

Air Force Long Supply Simulation
Sacramento Sample

SAFETY LEVEL REQUIREMENT BY QUARTER
(Thousands of Dollars)

QUARTER	SL=0	L=.1	L=100	L=555	L=1,000	L=100,000
1			126	513	652	941
2			119	497	628	893
3			109	458	577	819
4			95	434	518	799
5			71	393	471	688
6			72	362	477	704
7			65	358	472	701
8			56	313	420	648
9			29	261	374	613
10			30	255	365	590
11			29	235	335	560
12			31	228	319	533
13			25	186	267	458
14			22	141	261	510
15			22	393	517	886
16			21	401	537	812
17			21	384	513	846
18			17	314	424	715
19			16	330	445	723
20			17	293	396	650
21			16	154	238	465
22			14	129	200	350
23			11	98	158	287
24			9	89	143	266
25			8	84	132	252
26			7	83	132	238
27			7	78	123	221
28			7	76	120	220
29			6	75	120	216
30			7	78	127	239

L = SHORTAGE COST

TABLE 8

Air Force Long Supply Simulation
Sacramento Sample

ON HAND PLUS ON ORDER
(Millions of Dollars)

QUARTER	SL=0	L=100	L=555	L=1,000	L=100,000
1	2.5	2.7	3.1	3.2	3.5
2	2.6	2.7	3.1	3.3	3.6
3	2.5	2.6	3.0	3.2	3.5
4	2.4	2.5	2.9	3.1	3.1
5	2.3	2.4	2.8	3.0	3.3
6	2.3	2.5	2.9	3.0	3.3
7	2.3	2.4	2.9	3.0	3.4
8	2.3	2.4	2.8	3.0	3.3
9	2.3	2.4	2.8	2.9	3.3
10	2.2	2.3	2.7	2.9	3.2
11	2.2	2.3	2.7	2.9	3.3
12	2.2	2.3	2.7	2.9	3.2
13	2.2	2.3	2.7	2.8	3.2
14	2.2	2.3	2.7	2.9	3.3
15	2.8	3.0	3.6	3.7	4.3
16	2.9	3.0	3.6	3.8	4.3
17	2.9	3.0	3.6	3.8	4.3
18	2.8	2.9	3.5	3.7	4.3
19	2.7	2.8	3.4	3.6	4.2
20	2.7	2.8	3.4	3.6	4.2
21	2.7	2.8	3.4	3.6	4.1
22	2.7	2.8	3.3	3.5	4.1
23	2.6	2.7	3.3	3.5	4.0
24	2.6	2.6	3.2	3.4	4.0
25	2.6	2.6	3.2	3.4	3.9
26	2.5	2.6	3.1	3.3	3.9
27	2.5	2.5	3.1	3.3	3.8
29	2.4	2.5	3.0	3.2	3.8
30	2.4	2.5	3.1	3.3	3.8

L = SHORTAGE COST

TABLE 9 APPENDIX D

Air Force Long Supply Simulation
Sacramento Sample

New Procurement vs. New Long Supply

Shortage Cost = $390

(Dollars in Millions)

Year	New Procurement	New Long Supply	Percent
1	3.49*	0.15	4.30
2	0.55	0.44	80.00
3	0.49	0.17	34.69
4	1.45	0.13	8.97
5	0.37	0.42	113.51
6	0.22	0.80	363.64
7	0.20	-0.03	-15.00
7.5	0.17	-0.02	-11.76

* This value includes procurements required to set up the inventory stockage level assets.

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TABLE 10

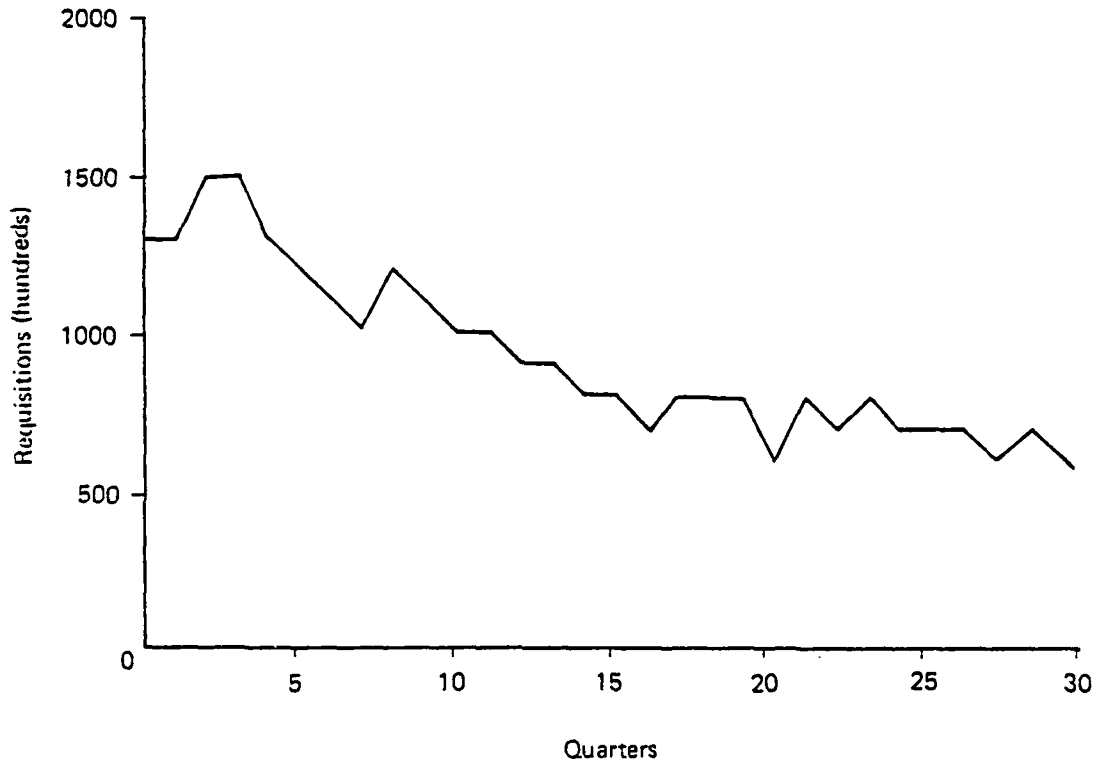
Air Force Long Supply Simulation
Sacramento Sample

MARGINAL ANALYSIS OF DATA AT END OF SIMULATION

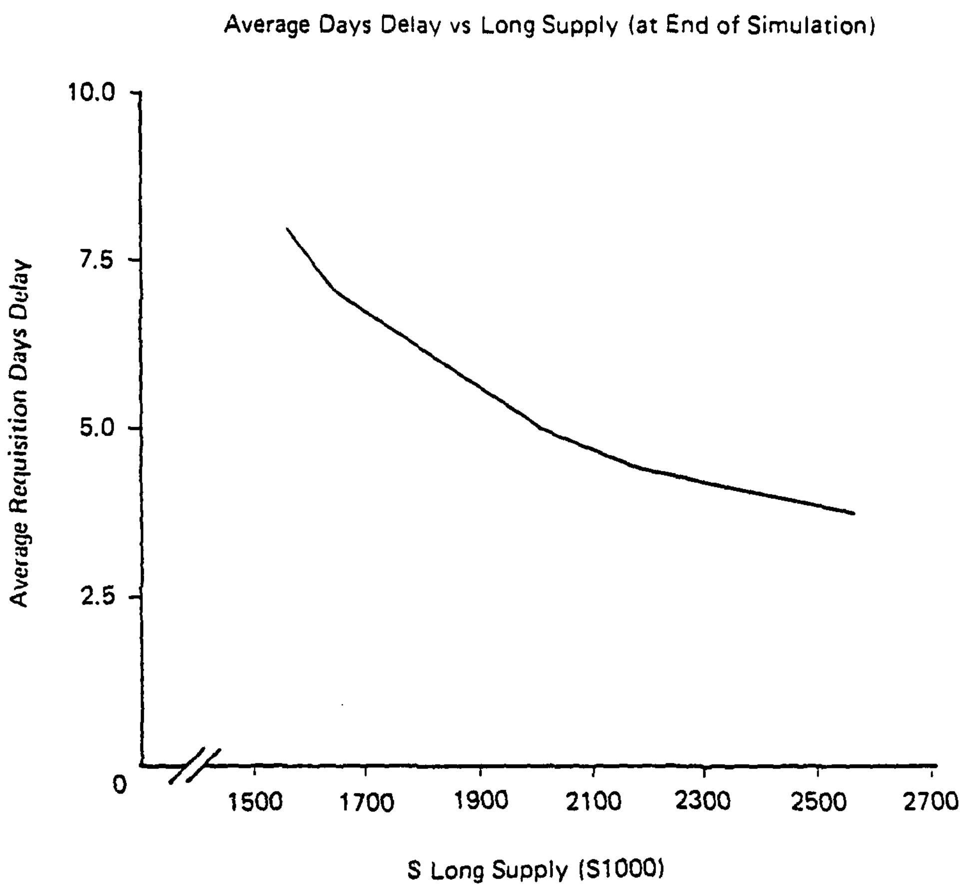
(Dollars in Thousands)

Change In Shortage Cost	Change In Dollar Value Of Procurements	Change In Dollar Value Of Long Supply	Percent Change In Requisition Fill Rate*	Percent Change In Average Days Delay*
$0.10 to $100	76.6	69.3	1.09	10.38 (0.82 Days)
$100 to $555	575.4	420.5	2.15	31.92 (2.26 Days)
$555 to $1000	202.8	131.5	0	11.41 (0.55 Days)
$1000 to $100,000	516.6	381.2	1.05	11.24 (0.48 Days)

* Percent change is the percent improvement and is equal to the change in the measure divided by the measurement at the lower shortage cost.

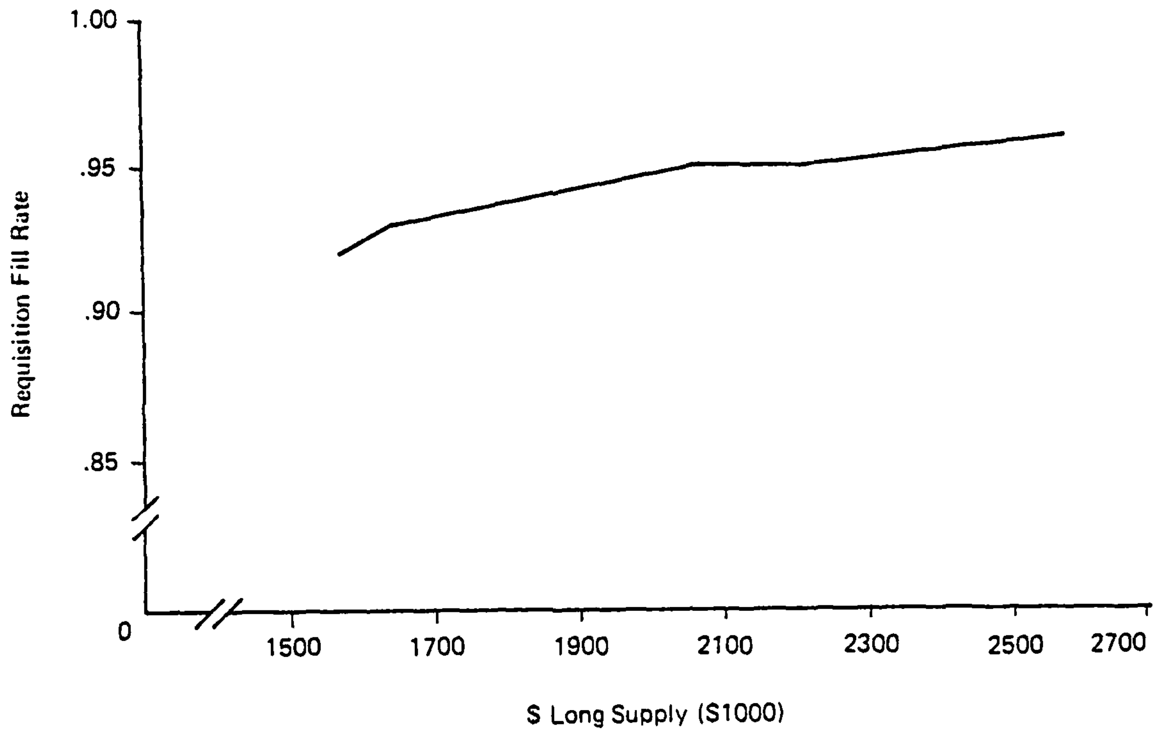


Appendix D, Graph 1
Air Force Long Supply Simulation
Sacramento ALC Sample
Requisition Trend During Simulation



Appendix D, Graph 2
Air Force Long Supply Simulation
Sacramento Sample

Requisition Fill Rate vs Long Supply (at End of Simulation)



Appendix D, Graph 3
Air Force Long Supply Simulation
Sacramento Sample

Appendix D, Graph 4
Air Force Long Supply Simulation
Sacramento Sample

ARMY VSL/EOQ SIMULATION

VSL/EOQ TASK NO. 0003

A. Scope and Methods

This study was conducted to evaluate the impact of the Army VSL/EOQ models, on long supply and materiel support. The study was limited to consumable, demand based, secondary items. The simulation model was developed by the U.S. Army Inventory Research Office for implementation of DoD Instruction 4140.39 and is a working tool used in many analyses of wholesale level stockage policies. A thorough description of the simulation model is provided in Reference (1) "ALPHA 4140.39 Simulator" (Appendix A).

The simulator operates on one item at a time. For each item, the demand history, the program history and the item-peculiar information (e.g. unit cost and leadtime forecast) used for computing stockage levels are provided as input to the simulator. The demand history is a quarterly record of both demand quantity (units) and demand frequency (requisitions). Likewise, there is a quarterly record of program data. Since the items used in the simulation were aviation items from the Army Troop Support and Aviation Readiness Command (TSARCOM), the program data was expressed in terms of flying hours. Procedures for collecting and maintaining the demand and program history data bases are described in Reference (2) "Data Base for NICP Oriented Problems" (Appendix A).

Other inputs to the simulator are the system costs and parameters needed to compute safety levels and order quantities: administrative cost-to-order, cost-to-hold rate and shortage cost. In addition, for medium and high dollar value items, a delivery cycle parameter is input in order to simulate the interval between receipts of phased-delivery procurement.

The inventory levels are computed in the simulator using the Army VSL/EOQ model implementing DoD Instruction 4140.39. Time is handled in discrete increments of 1.625 weeks (i.e. 32 time periods per year). Simulated assets are checked against the reorder point each period after the period demands are applied against the beginning of period assets. A procurement is generated if assets are less than the reorder point, and the quantity is equal to the order quantity plus the deficiency to the reorder point. The delivery of the procurement is simulated to occur a procurement leadtime after the buy is generated, and the procurement leadtime is assumed to be deterministic. For those items with incremental deliveries, the first delivery is simulated to occur at the end of the procurement leadtime and subsequent deliveries occur a delivery cycle apart.

An eleven year demand and program history was used covering the period 1967 through 1977. All demands are assumed to be recurring. The demand history input was constructed to make this assumption reasonable. The simulator breaks down the quarterly history into periods of 1.625 weeks in such a way that demand variability remains the same as in the quarterly history. The forecasted demand is computed from a two-year moving average of the past demand linearly adjusted by the program size.

For low dollar value items, the stockage levels are computed at least yearly, and at least quarterly for high dollar value items. All levels are recomputed whenever the reorder point is reached. The constraints of DoD Instruction 4140.39 were imposed except for those on safety level. The only constraint on safety level was that it be less than three standard deviations of leadtime demand.

The initial assets were set to the safety level plus one-half the order quantity, and these assets were simulated to be on-hand. The forecasted demand for the initial levels was based on the first two years of history. After the initialization, there was a two year warm-up period. Thus, the initial levels were based on the demand experienced during the first two years of the simulation.

At the end of the warm-up period, all performance statistics were cleared except the amount procured during the warm-up, including the initial assets. This was done since those assets could possibly migrate to long supply during the simulation. No disposal actions were simulated.

The items selected for this analysis were a sample of 6000 demand based, consumable, stock fund, aviation items managed by TSARCOM. To preclude the effect of special actions taken during phase-in and phase-out, only items with a complete program history were selected.

For this analysis, the simulator was modified to provide a new set of output statistics. At each six month period after warm-up, the total dollars in long supply, the total amount procured to date including the amount bought during warm-up, and two performance measures - stock availability and time weighted requisitions short - were recorded. Stock availability is accumulated after warm-up as the number of requisitions filled from stock on hand, including partial fills, divided by total requisitions received. In a similar way, time weighted requisitions short is an accumulation of requisitions on backorder counting only the portion of the requisition on backorder in cases of partial fill. Long supply for these simulations was composed of assets in excess of the requirements objective plus two years of forecasted demand. This simple measure was chosen to emulate the measure of long supply in stratification. Note that the measure of long supply is very much a function of the forecasted demand rate.

The tables and graphs of Appendix B provide the basic results of the simulation. Table 1 provides a snapshot picture of the output measurements for each of the three simulation runs (i.e. shortage costs of $1.00, $500 and $900) at six month intervals after the start of the simulation runs. Tables 2 through 6 are the same data displayed in a different format to show the results of all runs for all time intervals for each output measure. Table 7 shows the dollar value generation of new procurements versus the dollar value generation of long supply at yearly increments for the simulation run at a shortage cost of $500.

Table 8 shows a marginal analysis of changes in shortage cost to changes in procurements, long supply, requisition fill rate and average days delay. Graphs 1 through 3 display plots of the relationships of primary interest measures at the end of the simulation.

- o Average dollar value of long supply versus average dollar value of procurement (cumulative).
- o Requisition fill rate versus average dollar value of long supply.
- o Average days delay versus average dollar value of long supply.

Graph 4 displays a plot of the dollar value of long supply versus the dollar value of procurement (cumulative) during the simulation run at $500 shortage cost.

B. Conclusion and Findings

The following conclusions and findings are evident from the data of Appendix B.

- o The Army process for determining inventory stockage levels can contribute to long supply. This is evidenced in the data of Tables 1 through 6 and Graphs 1 and 4. This was particularly evident during the period of the Vietnam war drawdown. The contribution to long supply significantly lessened during the last years of the simulation as the effect of the Vietnam war washed out of the data base.
- o The long supply generated by the process is attributable primarily to the demand forecasting methodology rather than the VSL/EOQ stockage model. This conclusion is

drawn from an examination of Table 7 which shows that during the first three years of the simulation, net new long supply is on the order of 8-9% of new procurement. Suddenly, in the fourth year, this percentage becomes dramatically higher and approaches 50% in the sixth year. The breakpoint here is the latter part of 1970 which corresponds to the slackening of the war in Vietnam. Also from Table 7 it is noted that in the last two years of simulation there is actually a decrease in net new long supply. This highlights the fact that the VSL/EOQ stockage model, per se, does not produce long supply. Rather, long supply is primarily a function of the accuracy of the forecasts of demand which drive the VSL/EOQ computations.

o Increasing the safety level requirement (by increasing the shortage cost) increases the probability of long supply generation; however, an increased safety level results in a higher requisition fill rate and a lower average days delay (customer wait time per requisition). As shown on Tables 4 and 5, increasing the safety level (via an increased shortage cost) creates a higher dollar value of procurements and a higher dollar value of long supply throughout the simulation. On the other hand, Tables 2 and 3 show that increasing the safety level increases the requisition fill rate and reduces the average days delay throughout the simulation. Graphs 2 and 3 illustrate the relationship between the dollar value of long supply and requisition fill rate and average days delay. In addition, Graph 4 indicates the relationship of long supply and procurement investment, at the end of the simulation is nearly linear for the range of shortage costs examined. Another view of this data is portrayed in Table 8. This is a marginal view showing the additional amount of long supply, the additional amount

procured, and the improvement in supply performance measures at the end of the simulation. For example, changing the shortage cost from $1 to $500 generates $1076.25 more per item in procurement, and $459.41 more in long supply. So, about 43 cents of each additional dollar bought (for safety level primarily) migrates to long supply. On the other hand, there is a significant improvement in supply performance. The number of requisitions placed on backorder is reduced by 36.3% and average customer wait is reduced by 8.32 days. These results merely highlight how expensive it can be to raise supply performance to higher levels.

APPENDIX A

APPENDIX A

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1. Cohen, M.E., "ALPHA 4140.39 Simulator", AMC Inventory Research Office, Army Logistics Management Center, Ft. Lee, Virginia, May 1973, AD 762348.

2. Frazza, S., "Data Base for NICP Oriented Problems", U.S. Army Inventory Research Office, February 1980.

APPENDIX B

TABLE 1

Army Long Supply Simulation

Table of Summary Data at Six Months Intervals

	SHORTAGE COST		
	$ 1	$ 500	$ 900
SIMULATION + 6 MONTHS			
REQUISITION FILL RATE	0.661	0.771	0.807
AVERAGE DAYS DELAY	41.44	21.62	18.59
$ CUM. BUYS	13.78	14.52	15.36
$ LONG SUPPLY (LS)	0.44	0.54	0.66
$ LS ÷ $ CUM. BUYS	0.032	0.037	0.430
SIMULATION + 12 MONTHS			
REQUISITION FILL RATE	0.661	0.759	0.792
AVERAGE DAYS DELAY	47.98	31.88	25.70
$ CUM. BUYS	17.14	17.93	18.81
$ LONG SUPPLY (LS)	0.84	0.97	1.12
$ LS ÷ $ CUM. BUYS	0.049	0.054	0.060
SIMULATION + 18 MONTHS			
REQUISITION FILL RATE	0.667	0.758	0.790
AVERAGE DAYS DELAY	51.25	35.66	29.53
$ CUM. BUYS	20.20	21.03	21.94
$ LONG SUPPLY (LS)	1.08	1.21	1.37
$ LS ÷ $ CUM. BUYS	0.053	0.058	0.063
SIMULATION + 24 MONTHS			
REQUISITION FILL RATE	0.679	0.765	0.797
AVERAGE DAYS DELAY	50.16	35.12	29.53
$ CUM. BUYS	22.47	23.32	24.24
$ LONG SUPPLY (LS)	1.41	1.57	1.75
$ LS ÷ $ CUM. BUYS	0.063	0.067	0.072
SIMULATION + 30 MONTHS			
REQUISITION FILL RATE	0.695	0.780	0.810
AVERAGE DAYS DELAY	45.80	31.88	27.34
$ CUM. BUYS	24.29	25.15	26.08
$ LONG SUPPLY (LS)	1.44	1.62	1.80
$ LS ÷ $ CUM. BUYS	0.059	0.064	0.069

TABLE 1

Army Long Supply Simulation

Table of Summary Data at Six Months Intervals

	SHORTAGE COST		
	$ 1	$ 500	$ 900
SIMULATION + 36 MONTHS			
REQUISITION FILL RATE	0.720	0.799	0.827
AVERAGE DAYS DELAY	41 44	29.18	24.61
$ CUM. BUYS	25.43	26.34	27.33
$ LONG SUPPLY (LS)	1.59	1.80	2.01
$ LS ÷ $ CUM. BUYS	0.063	0.068	0.074
SIMULATION + 42 MONTHS			
REQUISITION FILL RATE	0.737	0.810	0.836
AVERAGE DAYS DELAY	37.62	26.48	22.97
$ CUM. BUYS	26.45	27.39	28.42
$ LONG SUPPLY (LS)	1.97	2.20	2.45
$ LS ÷ $ CUM. BUYS	0.075	0.080	0.086
SIMULATION + 48 MONTHS			
REQUISITION FILL RATE	0.753	0.821	0.845
AVERAGE DAYS DELAY	35.44	25.40	21.88
$ CUM. BUYS	27.49	28.46	29.51
$ LONG SUPPLY (LS)	2.08	2.34	2.59
$ LS ÷ $ CUM. BUYS	0.076	0.082	0.088
SIMULATION + 54 MONTHS			
REQUISITION FILL RATE	0.760	0.827	0.851
AVERAGE DAYS DELAY	34.35	24.31	20.78
$ CUM. BUYS	28.32	29.31	30.36
$ LONG SUPPLY (LS)	2.21	2.49	2.76
$ LS ÷ $ CUM. BUYS	0.078	0.085	0.091
SIMULATION + 60 MONTHS			
REQUISITION FILL RATE	0.766	0.833	0.856
AVERAGE DAYS DELAY	32.71	23.23	19.69
$ CUM. BUYS	28.91	29.23	30.98
$ LONG SUPPLY (LS)	2.48	2.80	3.11
$ LS ÷ $ CUM. BUYS	0.086	0.094	0.100

APPENDIX B

TABLE 1

Army Long Supply Simulation

Table of Summary Data at Six Months Intervals

	SHORTAGE COST		
	$ 1	$ 500	$ 900
SIMULATION + 66 MONTHS			
REQUISITION FILL RATE	0.771	0.837	0.859
AVERAGE DAYS DELAY	31.08	21.61	18.59
$ CUM. BUYS	29.34	30.39	31.44
$ LONG SUPPLY (LS)	2.59	2.93	3.25
$ LS ÷ $ CUM. BUYS	0.088	0.096	0.103
SIMULATION + 72 MONTHS			
REQUISITION FILL RATE	0.776	0.842	0.863
AVERAGE DAYS DELAY	29.99	21.07	18.05
$ CUM. BUYS	29.76	30.81	31.86
$ LONG SUPPLY (LS)	2.81	3.22	3.59
$ LS ÷ $ CUM. BUYS	0.095	0.104	0.113
SIMULATION + 78 MONTHS			
REQUISITION FILL RATE	0.781	0.846	0.868
AVERAGE DAYS DELAY	28.35	19.45	16.95
$ CUM. BUYS	30.21	31.27	32.31
$ LONG SUPPLY (LS)	2.98	3.41	3.81
$ LS ÷ $ CUM. BUYS	0.099	0.109	0.118
SIMULATION + 84 MONTHS			
REQUISITION FILL RATE	0.785	0.852	0.874
AVERAGE DAYS DELAY	27.26	18.91	15.86
$ CUM. BUYS	30.75	31.80	32.85
$ LONG SUPPLY (LS)	2.99	3.43	3.83
$ LS ÷ $ CUM. BUYS	0.097	0.108	0.117
SIMULATION + 30 MONTHS			
REQUISITION FILL RATE	0.788	0.858	0.878
AVERAGE DAYS DELAY	26.72	17.83	15.31
$ CUM. BUYS	31.19	32.26	33.31
$ LONG SUPPLY (LS)	2.95	3.40	3.80
$ LS ÷ $ CUM. BUYS	0.095	0.105	0.114

TABLE 1 APPENDIX B

Army Long Supply Simulation

Table of Summary Data at Six Months Intervals

	SHORTAGE COST		
	$ 1	$ 500	$ 900
SIMULATION + 96 MONTHS			
REQUISITION FILL RATE	0.791	0.862	0.883
AVERAGE DAYS DELAY	25.63	17.29	14.77
$ CUM. BUYS	31.70	32.78	33.83
$ LONG SUPPLY (LS)	2.90	3.35	3.74
$ LS ÷ $ CUM. BUYS	0.091	0.102	0.111
SIMULATION + 102 MONTHS			
REQUISITION FILL RATE	0.793	0.866	0.887
AVERAGE DAYS DELAY	25.08	16.21	13.67
$ CUM. BUYS	32.27	33.34	34.39
$ LONG SUPPLY (LS)	2.86	3.30	3.70
$ LS ÷ $ CUM. BUYS	0.088	0.099	0.108
SIMULATION + 108 MONTHS			
REQUISITION FILL RATE	0.796	0.870	0.890
AVERAGE DAYS DELAY	23.99	15.67	13.13
$ CUM. BUYS	32.78	33.85	34.89
$ LONG SUPPLY (LS)	2.88	3.34	3.75
$ LS ÷ $ CUM. BUYS	0.088	0.099	0.107

TABLE 2

Army Long Supply Simulation

REQUISITION FILL RATE

	SHORTAGE COST		
	1.00	500	900
6 Months	0.661	0.771	0.807
12 Months	0.661	0.759	0.792
18 Months	0.667	0.758	0.790
24 Months	0.679	0.765	0.797
30 Months	0.695	0.780	0.810
36 Months	0.720	0.799	0.827
42 Months	0.737	0.810	0.836
48 Months	0.753	0.821	0.845
54 Months	0.760	0.827	0.851
60 Months	0.766	0.833	0.856
66 Months	0.771	0.837	0.859
72 Months	0.776	0.842	0.863
78 Months	0.781	0.846	0.868
84 Months	0.785	0.852	0.874
90 Months	0.788	0.858	0.878
96 Months	0.791	0.862	0.883
102 Months	0.793	0.866	0.887
108 Months	0.796	0.870	0.890

TABLE 3 APPENDIX B

Army Long Supply Simulation

AVERAGE DAYS DELAY

	SHORTAGE COST		
	1.00	500	900
6 Months	41.44	21.62	18.59
12 Months	47.98	31.88	25.70
18 Months	51.28	35.66	29.53
24 Months	50.16	35.12	29.53
30 Months	45.80	31.88	27.34
36 Months	41.44	29.18	24.61
42 Months	37.62	26.48	22.97
48 Months	35.44	25.40	21.88
54 Months	34.35	24.31	20.78
60 Months	32.71	23.23	19.69
66 Months	31.08	21.61	18.59
72 Months	29.99	21.07	18.05
78 Months	28.35	19.45	16.95
84 Months	27.26	18.91	15.86
90 Months	26.72	17.83	15.31
96 Months	25.63	17.29	14.77
102 Months	25.08	16.21	13.67
108 Months	23.99	15.67	13.13

TABLE 4 APPENDIX B

Army Long Supply Simulation

$ CUMULATIVE BUYS

(Dollars in Thousands)

	SHORTAGE COST		
	1.00	500	900
6 Months	13778	14516	15362
12 Months	17139	17928	18808
18 Months	20201	21031	21938
24 Months	22467	23316	24240
30 Months	24285	25152	26084
36 Months	25432	26344	27334
42 Months	26451	27394	28423
48 Months	27489	28465	29512
54 Months	29322	29314	30356
60 Months	28909	29927	30978
66 Months	29339	30392	31444
72 Months	29757	30806	31863
78 Months	30212	31266	32310
84 Months	30754	31803	32850
90 Months	31192	32257	33308
96 Months	31703	32782	33834
102 Months	32266	33341	34393
108 Months	32776	33852	34890

TABLE 5

Army Long Supply Simulation

$ LONG SUPPLY

(Dollars in Thousands)

	SHORTAGE COST		
	1.00	500	900
6 Months	441.53	543.30	660.35
12 Months	844.55	973.00	1119.57
18 Months	1077.83	1214.55	1374.02
24 Months	1408.93	1566.45	1747.25
30 Months	1439.56	1615.92	1802.70
36 Months	1594.76	1799.71	2013.20
42 Months	1972.74	2204.81	2450.12
48 Months	2083.96	2340.31	2593.98
54 Months	2211.83	2489.09	2761.96
60 Months	2480.12	2803.12	3110.35
66 Months	2590.61	2931.09	3247.20
72 Months	2814.21	3218.22	3586.89
78 Months	2982.16	3413.80	3805.74
84 Months	2986.17	3432.40	3834.05
90 Months	2950.71	3403.20	3803.76
96 Months	2898.88	3348.32	3743.30
102 Months	2855.28	3301.97	3701.45
108 Months	2879.77	3339.18	3745.47

T A B L E 6

APPENDIX B

Army Long Supply Simulation

$ LONG SUPPLY ÷ $ CUMULATIVE BUYS

	SHORTAGE COST		
	1.00	500	900
6 Months	0.032	0.037	0.043
12 Months	0.049	0.054	0.059
18 Months	0.053	0.058	0.063
24 Months	0.063	0.067	0.072
30 Months	0.059	0.064	0.069
36 Months	0.063	0.068	0.074
42 Months	0.075	0.080	0.086
48 Months	0.076	0.082	0.088
54 Months	0.078	0.085	0.091
60 Months	0.086	0.094	0.100
66 Months	0.088	0.096	0.103
72 Months	0.095	0.104	0.113
78 Months	0.099	0.109	0.118
84 Months	0.097	0.108	0.117
90 Months	0.095	0.105	0.114
96 Months	0.091	0.102	0.111
102 Months	0.088	0.099	0.108
108 Months	0.088	0.099	0.107

TABLE 7 APPENDIX B

NEW PROCUREMENT VS. NEW LONG SUPPLY

Shortage Cost = $ 500

Year	New Procurement	New Long Supply	Percent
1	17,928.4*	973.0	5.43
2	5,387.83	593.0	11.01
3	3,027.71	233.26	7.70
4	2,120.72	540.6	25.49
5	1,462.82	462.81	31.64
6	878.92	415.1	47.23
7	996.17	214.18	21.50
8	979.11	-84.08	-8.59
9	1,070.69	-9.14	-0.85

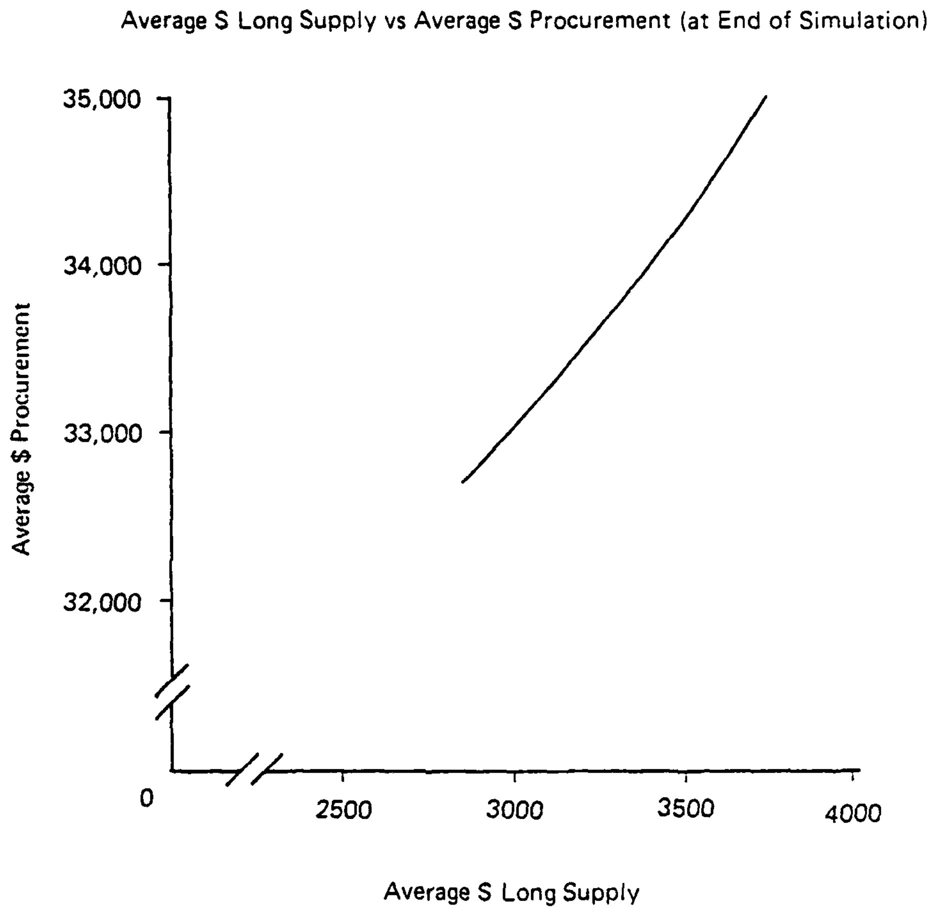
* Note that this value includes the dollars needed to set up supply levels and is therefore much larger than subsequent new procurement which is basically just replenishment of supply levels.

TABLE 8 APPENDIX B

MARGINAL ANALYSIS OF DATA AT END OF SIMULATION

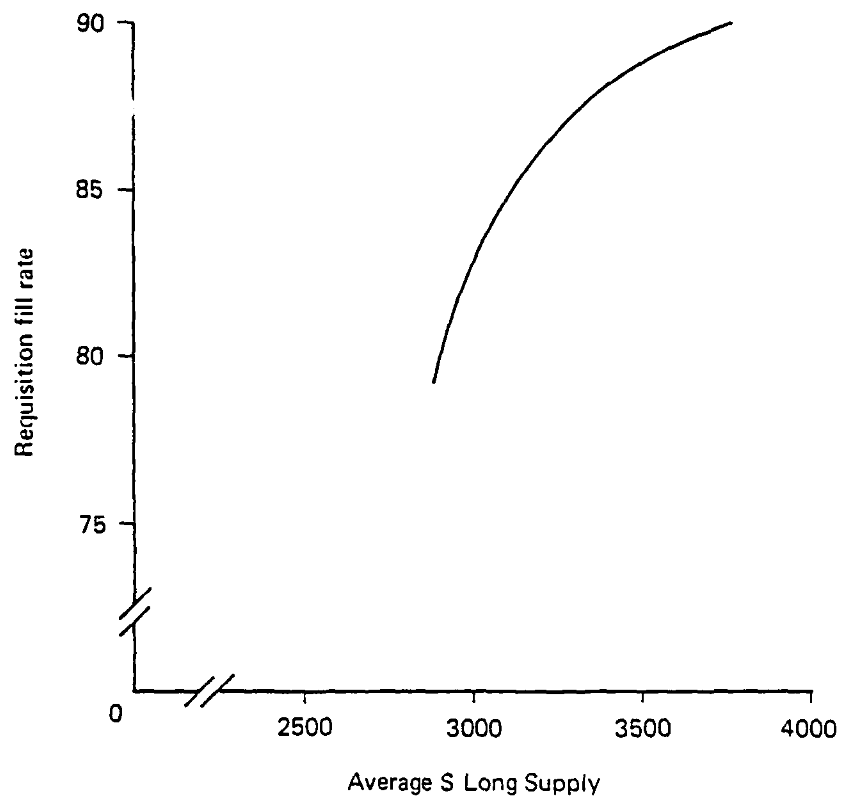
Change In Shortage Cost	Change In Dollar Value of Procurement	Change In Dollar Value of Long Supply	Percent Change In Requisition Fill Rate*	Percent Change In Average Days Delay*
$1 to $500	1,076.25	459.41	36.27%	34.7 (8.32 Days)
$500 to $900	1,037.66	404.29	15.4%	16.2 (2.54 Days)

* Percent Change In Fill Rate (and Days Delay) = Percent Improvement in backordered requisitions (or Days Delay) divided by change in backordered requisitions (or Days Delay) at lower shortage cost value.

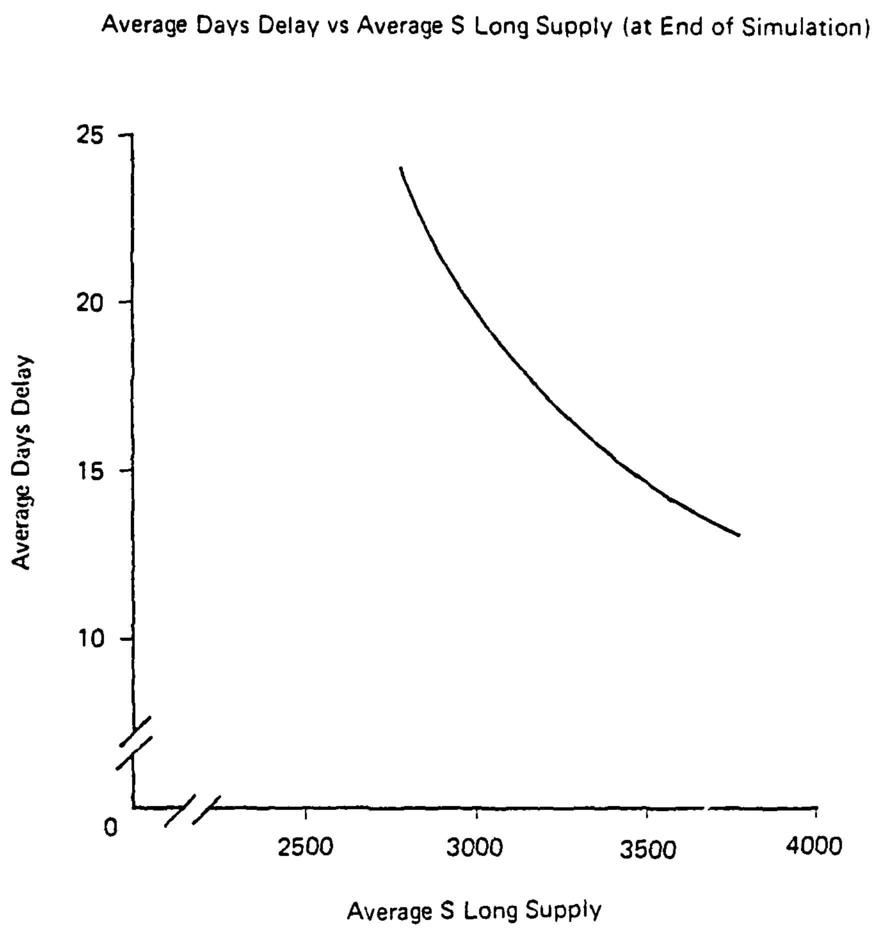


Appendix B, Graph 1
Army Long Supply Simulation

Requisition Fill Rate vs Average S Long Supply (at End of Simulation)

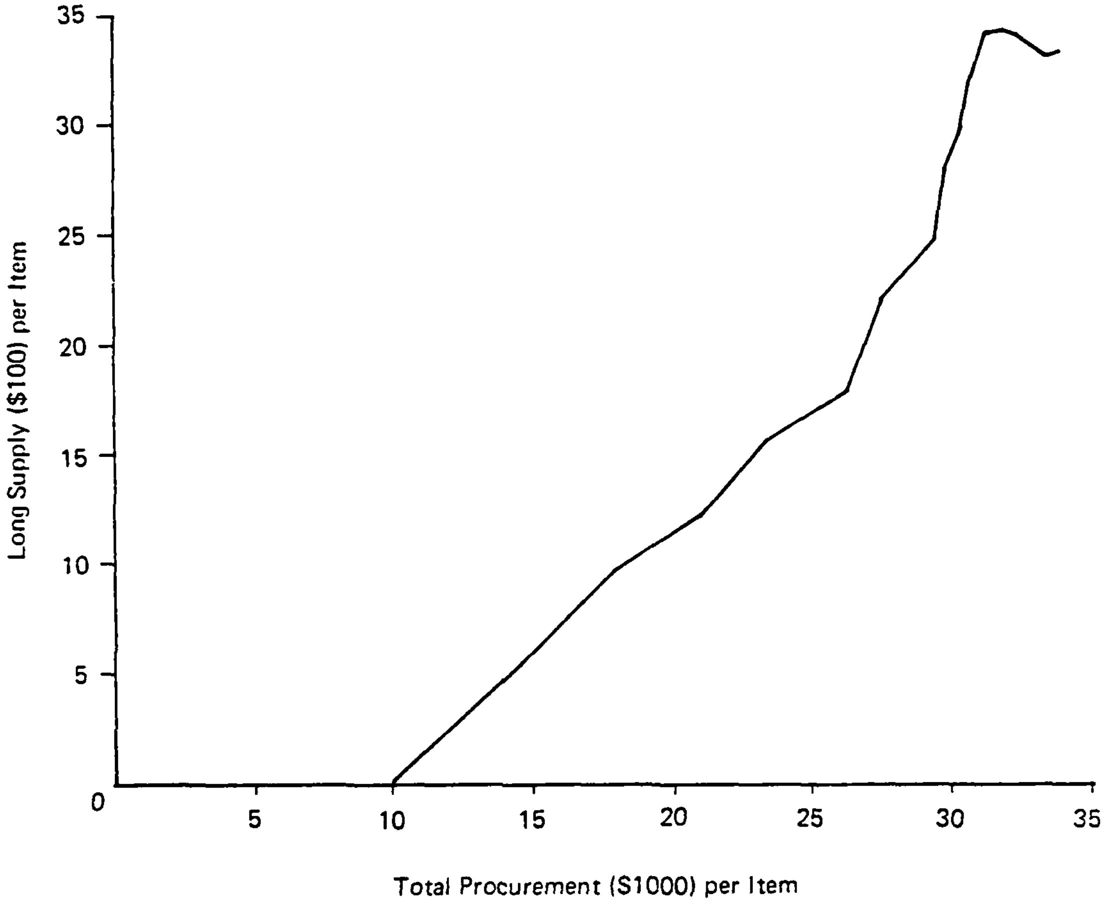


Appendix B, Graph 2
Army Long Supply Simulation



Appendix B, Graph 3
Army Long Supply Simulation

Long Supply vs Total Procurement
Shortage Cost = 500



Appendix B, Graph 4
Army Long Supply Simulation

DEFENSE LOGISTICS AGENCY VSL/EOQ SIMULATION

VSL/EOQ TASK NO. 0003

A. Scope and Methods

This study was conducted to evaluate the impact of the VSL/EOQ models, implemented by DLA, upon long supply and material support. The study involved consumable, demand based, secondary items. The DLA Uniform Standard Automated Material Management System (SAMMS) Inventory Management Simulation (USIMS) was used to test and quantify the impact of various inventory control policies for this study.

The USIMS simulator is a part of the DLA SAMMS package provided each Defense Supply Center. While it has been designed and maintained by operations research professionals, USIMS is intended to be used by supply managers to test the effect of policy and environmental changes on supply performance and inventory investment. For the purpose of this study, USIMS was also used to demonstrate the effect on long supply of varying the safety level investment.

USIMS is a discrete event Monte Carlo single item inventory simulation model. It simulates those segments of the SAMMS requirements and distribution subsystems and decisions relating to supply performance and investment. The period of simulation is 24 months of supply activity including demands, returns, levels computation, procurement review and receipts of material. Because it uses the sample items' actual asset and requirement postures at the time the sample is selected, there is no warm-up or initialization period.

Basic assumptions and features of USIMS include:

> Demands and returns are assumed to have exponential interarrival times and a lognormal quantity distribution. The requisition priority distribution is derived empirically from historical

data. All distribution parameters are drawn from a four quarter demand and returns history for each item.

Demand variance is expressed as a function of the variance to mean-square ratio.

Leadtimes are generated according to an empirical distribution developed at the Defense Industrial Supply Center (DISC). Each item's leadtime of record is used as the mean.

The items selected for this study were a sample of 5,700 items from the Defense Industrial Supply Center (DISC). The sample was extracted from the DISC files following the 30 December 1979 requirements forecast. The sample was drawn in proportion to the DSC's inventory of items in each of these value of annual demand categories:

$ 0.01 - $ 400
$ 400 - $ 4,500
$ 4,500 - $ 15,000
$ 15,000 - $ 50,000
$ 50,000 - $ 100,000
Over $ 100,000

To have been selected, the item must have been in the system for at least two years and have had complete demand data during the year prior to extraction. The item data input to the simulator included demand and returns history, asset (on-hand, on-order, due-out) data, unit cost and leadtime.

The simulation output provided monthly statistics for various measures. These have been reproduced at six month intervals as Table 1 of Appendix A. The output measures are requisition fill rate, average days delay, dollar value of procurements, dollar value of safety level, dollar value of assets (on-hand plus on-order minus backorders), the dollar value change (Δ) in long supply and the ratio of the change (Δ) in long

supply to procurements. The change in long supply was used because the simulation did not begin in a "balanced" asset-to-requirements position and long supply assets were in existence then.

Appendix A provides a table of the output statistics. Graphs are not provided since the output data did not reflect significant changes to long supply except for the maximum parameter setting for safety level.

B. Findings and Conclusions

The limited horizon of the DLA simulation did not permit a long-term assessment of the potential of the model for generating long supply. Long supply figures are skewed by the changes to the safety levels occurring at the front end of the simulation. The amount of long supply is initially reduced in the maximum safety level simulation; it then increases throughout the remainder of the simulation. In the low safety level simulations, the long supply caused by the initial reduction in safety levels had migrated back into balance by the end of the simulation.

Note that the correlations between safety level and requisition fill rate and between safety level and average days delay do not become pronounced until the end of the simulation. Both of these correlations would be expected to become more pronounced if the simulation horizon was extended beyond two years. The minimum safety level computed in the DLA simulation corresponds to a shortage cost (λ) of $14.40. This would cause a small safety level to be computed on some low price items with irregular demand. Additionally, DLA maintains Fleet Issue Load List (FILL) requirements at NSC Norfolk and NSC Oakland. These FILL requirements, which were in the simulation, have the effect of minimum safety levels. These reasons account for the residual safety levels when the parameters are reduced to the minimum in the simulations.

In summary, the DLA simulations did not conclusively evaluate the

potential of the model for producing long supply. For this reason, no DLA graphics are included. The simulations did demonstrate the comparative effects which would be expected for extreme minimum and maximum safety levels. The use of a longer simulation horizon would have provided more conclusive data.

APPENDIX A

TABLE 1 APPENDIX A

DLA VSL/EOQ SIMULATION

(Dollars in Millions)

	MAX B=1	B=25K	40K	300K	MIN 1 MIL
6 Months					
Requisition Fill Rate	92.5	92.6	92.5	92.5	92.5
Average Days Delay	7.3	7.3	7.4	7.0	6.9
$ Procurement	415.1	258.1	242.9	219.0	217.0
$ Safety Level	201.1	67.0	50.0	7.0	1.6
$ Assets	766.9	647.3	629.7	606.4	664.1
Δ $ Long Supply	+ 3.4	+ 3.0	+ 4.2	+ 4.0	+ 4.0
Ratio (ΔLS/Procurement)%	+ 0.8	+ 1.2	+ 1.7	+ 1.8	+ 1.8
12 Months					
Requisition Fill Rate	94.3	94.2	94.1	94.0	93.9
Average Days Delay	7.2	6.6	6.7	6.9	6.7
$ Procurement	644.0	453.2	431.0	384.0	380.0
$ Safety Level	208.3	77.0	58.3	8.3	2.3
$ Assets	844.4	671.7	653.8	615.2	652.9
Δ $ Long Supply	+ 2.8	+ 1.0	+ 2.0	+ 2.0	+ 3.0
Ratio (ΔLS/Procurement)%	+ 0.4	+ 0.2	+ 0.5	+ 0.5	+ 0.8
18 Months					
Requisition Fill Rate	95.3	94.8	94.6	93.9	93.7
Average Days Delay	5.9	5.9	6.2	6.7	6.9
$ Procurement	928.6	704.1	679.1	631.1	626.1
$ Safety Level	215.8	82.3	63.0	9.6	3.1
$ Assets	905.7	730.8	713.9	663.9	659.5
Δ $ Long Supply	+ 4.2	-	-	-	+ 1.0
Ratio (ΔLS/Procurement)%	+ 0.5%	-	-	-	+ 0.2%
24 Months					
Requisition Fill Rate	95.8	95.1	94.8	93.3	92.8
Average Days Delay	4.8	5.6	5.8	6.9	7.4
$ Procurement	1,140.6	893.0	867.0	810.9	805.3
$ Safety Level	245.7	84.6	65.3	9.6	2.6
$ Assets	1,008.1	798.6	781.8	728.5	732.5
Δ $ Long Supply	+10.4	- 2.0	- 2.0	- 2.0	- 2.0
Ratio (ΔLS/Procurement)%	+ 0.9%	- 0.2%	- 0.2%	- 0.2%	- 0.2%

B=βeta setting

NAVY VSL/EOQ SIMULATION

VSL/EOQ TASK NO. 0003

A. Scope and Methods

This study was undertaken to evaluate the impact of the Navy VSL/EOQ models on long supply and material support. The study examined consumable, demand-based, secondary items in a modified version of the Navy 5A (Aviation Afloat and Allowance Analyzer) wholesale inventory simulator, in order to test and quantify the impact of various inventory policies (parameter settings) for this study.

The basic Navy 5A wholesale simulator replicates the inventory management operations at ASO. For use in this study, the simulator was modified to incorporate the salient features of the inventory management operations at SPCC and to provide specific output information required for this study. For example, one of the modifications involved the computation of long supply so that assets would be classified long supply in the amount the inventory position (on-hand plus on-order minus backorders) exceeded the requirements objective plus two years' forecasted demand.

Since the simulator replicated the Navy Supply System, the assumptions of the ICP VSL/EOQ models were incorporated in the simulator. In addition assumptions and features unique to the simulator were:

> Items do not interact; the possibility of substituting a different item to fill a requisition was not modelled. This assumption allowed each item to be simulated separately.
>
> All system parameters (e.g. shortage cost, cost to hold, etc.) are held constant throughout the simulated time period.
>
> The initial demand forecast is equal to the simple average of

the observed quarterly demand during the first two quarters of the demand history. This assumption was necessary since the forecast of demand is not saved on any historical file.

The initial reorder point and order quantity is computed based on the initial demand forecast.

The initial on-hand quantity is equal to the reorder point plus one-half the order quantity. All items began the simulation runs with zero backorders and no orders outstanding.

Disposals do not occur. Assets which become long supply are not disposed.

Special, fixed requirements and reservations were not modeled.

A fixed percentage of the nonrecurring demands were simulated. The demand history contained both recurring and nonrecurring demand transactions. Some of the nonrecurring demands were for special, fixed requirements, while others were miscoded by the customer. Based on historical data, a percentage of the nonrecurring demands which were not for special requirements was determined. That percentage of the nonrecurring demands were included as though they were recurring demands, except for forecasting. When these demands occurred in the simulation, materiel was issued if available. Otherwise, the requisition was backordered or specially procured, as appropriate. These demands were in the measurements of requisition fill rate, average days delay and procurements. However, they were not in the demand forecasts since Navy's forecasting rules do not include nonrecurring demands. The nonrecurring demands which were not simulated were assumed to be satisfied when required and are included in the requisition fill rate and average days delay.

The simulation incorporated the constraints of the ICP VSL/ EOQ models. It should be noted that the safety level constraint of the mean leadtime demand was not in the simulator since it has not been incorporated in the ICP VSL/EOQ models to date. On the other hand, it should also be noted that Navy utilizes the concept of risk constraints and that the minimum risk constraint of 0.01 (used in this study) is equivalent to a maximum safety level of 2.33 times the standard deviation (σ) of leadtime demand for a normal distribution (DoD Instruction 4140.39 permits up to 3σ).

Approximately 90 different parameters are available to the simulator user. However, most of these do not affect the VSL/EOQ computations. The parameters which impacted on long supply are discussed below:

> The shortage cost was varied to achieve different safety level and effectiveness goals. The remaining parameters were held constant for the sensitivity analysis. Examples of these parameters include: obsolescence rate, interest rate, ordering costs and minimum order quantity.
>
> Other parameters which may constrain the VSL/EOQ model were set so that the constraint would not be active. Examples of these parameters include: MSLS (Months of Safety Level Stock), minimum and maximum risk constraints. The MSLS parameter constrains the safety level to be no more than a specified number of months of stock. In this study the MSLS parameter was set to 99 and the constraint was not active. The minimum and maximum risk constraints were set at .01 and .99. Thus, the acceptable risk was allowed to range between .01 and .99 unconstrained.
>
> One parameter which does affect VSL/EOQ was not changed to be inactive - MNPCTZ, minimum percentage of leadtime demand. MNPCTZ constrains the safety level to be at least as large as some specified percentage of leadtime demand. For

> ASO material, MNPCTZ was set to 1.0 while for SPCC materiel, MNPCTZ was set to 0.0 to conform with ICP operations. Thus, the safety level for ASO items was constrained to be no less than zero while negative safety levels were permitted for SPCC items.

Two random samples of items were selected from the historical records of the two Navy ICPs - 1,911 items from the Aviation Supply Office (ASO) and 2,005 from the Ships Parts Control Center (SPCC). The items selected were not managed on program relationships (e.g., flying hours). The primary item information input to the simulator was the replacement unit cost, the mean procurement leadtime, the standard deviation of procurement leadtime and the demand history. The demand history was the actual time-phased stream of demand transactions. For ASO items the demand transactions covered the three year period of November 1975 through November 1978; while for SPCC items, 6 years were covered from January 1974 through December 1979.

The simulator operation consisted of a series of time-oriented routines associated with the basic inventory control functions including requisition processing, procurement review, receipt of material from procurements, demand forecasting and inventory stockage levels computation. All processing occurred on an item by item basis. Impetus to the simulator was the actual historical demand requisitions which had been placed on the Navy Supply System. In the simulation, requisitions were considered satisfied only if enough material was available to satisfy the entire requisition quantity. When the inventory reached or fell below the reorder point, a purchase action was simulated, and the receipt of the material occurred at the end of a leadtime. Leadtimes were not considered deterministic but rather were generated using a normally distributed pseudorandom number and the item's forecasted mean and standard deviation of procurement leadtime. The demand forecasts, reorder points and order quantities were computed on a quarterly basis.

Each sample was used in five separate simulation runs. In one run, the safety level was held at zero throughout the simulation. The four remaining runs were made with essentiality-weighted shortage costs of $0.50, $5.00, $50.00 and the maximum shortage cost setting.

For this analysis, the simulator provided statistics at the end of each six months period following the warm-up period, which was 1 year for ASO items and 2 years for SPCC items. The statistics generated included the requisition fill rate, the average days delay, the dollar value of procurements, the dollar value of long supply assets, the dollar value of on-hand and on-order assets, and the ratio of long supply with respect to procurements.

Appendix A provides tables and graphs reflecting the results of the simulation for ASO items. Appendix B provides tables and graphs for SPCC items. There are two formats of tabular data. Table 1 of the appendixes provides a snapshot of the output measures for each of the five simulation runs (i.e., zero safety level, $0.50, $5.00, $50.00, and maximum safety level) at six month intervals for each output measure. Tables 2 through 8 display the Table 1 data in a different format--by output measure over the simulation horizon. Table 9 shows a marginal analysis of changes in shortage cost to changes in the various output measures. Graphs 1 through 3 display plots of these relationships:

Dollar value of long supply versus dollar value of procurement.

Requisition fill rate versus the dollar value of long supply.

Average days delay versus the dollar value of long supply.

Appendix C defines the output measures of this study.

B. Findings and Conclusions

The tables and graphs of the appendixes show that long supply is

generated during the simulation. Furthermore they show that the greater the safety level investment (via greater shortage costs), the greater the long supply and value of procurements. However, the increased safety level does provide the benefits of increased requisition fill rate and decreased average days delay.

Graph 1 of the appendices shows that the improvement in average days delay follows the law of diminishing returns with respect to the growth in long supply. However, except for the impact of the negative safety levels for the SPCC items, the improvement in requisition fill rate is nearly linear with respect to increases in long supply, as reflected by Graph 2 of the appendices. Concerning the relationship of procurements to long supply, Graph 3 of the appendices reflects the condition that as procurements increase (due to safety level increases) an amount migrates to long supply at an increasing rate. This is also reflected in the data of Table 9.

It should be noted that the results for SPCC reflect a simulation in which negative safety levels are permitted, while for ASO the safety levels are restricted to be nonnegative.

APPENDIX A

TABLE 1

APPENDIX A

Navy Long Supply Simulation
Aviation Supply Office Sample

(Dollar Values In Millions)

SHORTAGE COST SETTINGS	SL=0	0.50	5.00	50.00	Maximum
SIMULATION + 6 MONTHS					
REQUISITION FILL RATE	67.4	68.0	75.8	79.7	87.8
AVERAGE DAYS DELAY	20.8	18.9	14.4	13.6	6.1
$ PROCUREMENTS (BUYS)	53.2	54.7	67.6	87.3	106.2
$ LONG SUPPLY (LS)	0.2	0.7	2.5	6.1	7.1
$ LS ÷ $ BUYS	0.004	0.013	0.037	0.070	0.067
$ SAFETY LEVEL	0	2.6	14.5	31.2	43.7
$ ON HAND + ON ORDER	27.4	29.5	41.5	60.2	78.4
SIMULATION + 12 MONTHS					
REQUISITION FILL RATE	62.4	64.8	72.8	78.0	86.4
AVERAGE DAYS DELAY	32.4	28.7	20.3	18.1	10.6
$ PROCUREMENT (BUYS)	68.4	70.9	86.6	108.5	125.7
$ LONG SUPPLY (LS)	0.4	1.0	2.8	5.8	7.4
$ LS ÷ $ BUYS	0.006	0.014	0.032	0.053	0.059
$ SAFETY LEVEL	0	4.1	18.4	37.6	51.1
$ ON HAND + ON ORDER	31.7	34.8	48.5	68.9	83.5
SIMULATION + 18 MONTHS					
REQUISITION FILL RATE	60.2	63.8	72.0	78.3	86.1
AVERAGE DAYS DELAY	41.4	37.8	26.6	20.9	12.8
$ PROCUREMENT (BUYS)	83.4	87.3	105.4	130.0	145.4
$ LONG SUPPLY (LS)	0.7	1.4	4.1	7.4	10.8
$ LS ÷ $ BUYS	0.009	0.016	0.039	0.057	0.074
$ SAFETY LEVEL	0	4.7	20.3	39.9	47.8
$ ON HAND + ON ORDER	36.4	38.0	55.2	77.0	89.7
SIMULATION + 24 MONTHS					
REQUISITION FILL RATE	57.1	61.5	71.2	77.2	85.0
AVERAGE DAYS DELAY	54.8	45.9	31.1	23.1	16.9
$ PROCUREMENT (BUYS)	101.2	107.2	129.1	158.8	170.4
$ LONG SUPPLY (LS)	1.0	1.7	5.0	8.5	11.7
$ LS ÷ $ BUYS	0.010	0.016	0.039	0.054	0.069
$ SAFETY LEVEL	0	6.4	23.2	44.5	53.8
$ ON HAND + ON ORDER	41.7	44.1	63.3	91.0	98.9

Navy Long Supply Simulation
Aviation Supply Office Sample

TABLE 2

REQUISITION FILL RATE

START OF SIMULATION PLUS:	SL=0	0.50	5.00	50.00	Maximum
		Shortage Cost Settings			
6 Months	67.4	68.0	75.8	79.7	87.8
12 Months	62.4	64.8	72.8	78.0	86.4
18 Months	60.2	63.8	72.0	78.3	86.1
24 Months	57.1	61.5	71.2	77.2	85.0

TABLE 3

AVERAGE DAYS DELAY

START OF SIMULATION PLUS:					
6 Months	20.8	18.9	14.4	13.6	6.1
12 Months	32.4	28.7	20.3	18.1	10.6
18 Months	41.4	37.8	26.6	20.9	12.8
24 Months	54.8	45.9	31.1	23.1	16.9

TABLE 4

DOLLAR VALUE OF PROCUREMENTS ($M)

START OF SIMULATION PLUS:					
6 Months	53.2	54.7	67.6	87.3	106.2
12 Months	68.4	70.9	86.6	108.5	125.7
18 Months	83.4	87.3	105.4	130.0	145.4
24 Months	101.2	107.2	129.1	158.8	170.4

TABLE 5

DOLLAR VALUE OF LONG SUPPLY ($M)

START OF SIMULATION PLUS:					
6 Months	0.2	0.7	2.5	6.1	7.1
12 Months	0.4	1.0	2.8	5.8	7.4
18 Months	0.7	1.4	4.1	7.4	10.8
24 Months	1.0	1.7	5.0	8.5	11.7

Navy Long Supply Simulation
Aviation Supply Office Sample

TABLE 6

RATIO OF $ LONG SUPPLY ÷ $ PROCUREMENT

	Shortage Cost Settings				
	SL=0	0.50	5.00	50.00	Maximum
START OF SIMULATION PLUS:					
6 Months	0.004	0.013	0.037	0.070	0.067
12 Months	0.006	0.014	0.032	0.053	0.059
18 Months	0.009	0.016	0.039	0.057	0.074
24 Months	0.010	0.016	0.039	0.054	0.069

TABLE 7

DOLLAR VALUE OF SAFETY LEVEL

START OF SIMULATION PLUS:					
6 Months	0	2.6	14.5	31.2	43.7
12 Months	0	4.1	18.4	37.6	51.1
18 Months	0	4.7	20.3	39.9	47.8
24 Months	0	6.4	23.2	44.5	53.8

TABLE 8

DOLLAR VALUE OF ON-HAND + ON-ORDER ASSETS

START OF SIMULATION PLUS:					
6 Months	27.4	29.5	41.5	60.2	78.4
12 Months	31.7	34.8	48.5	68.9	83.5
18 Months	36.4	38.0	55.2	77.0	89.7
24 Months	41.7	44.1	63.3	91.0	98.9

TABLE 9 APPENDIX A

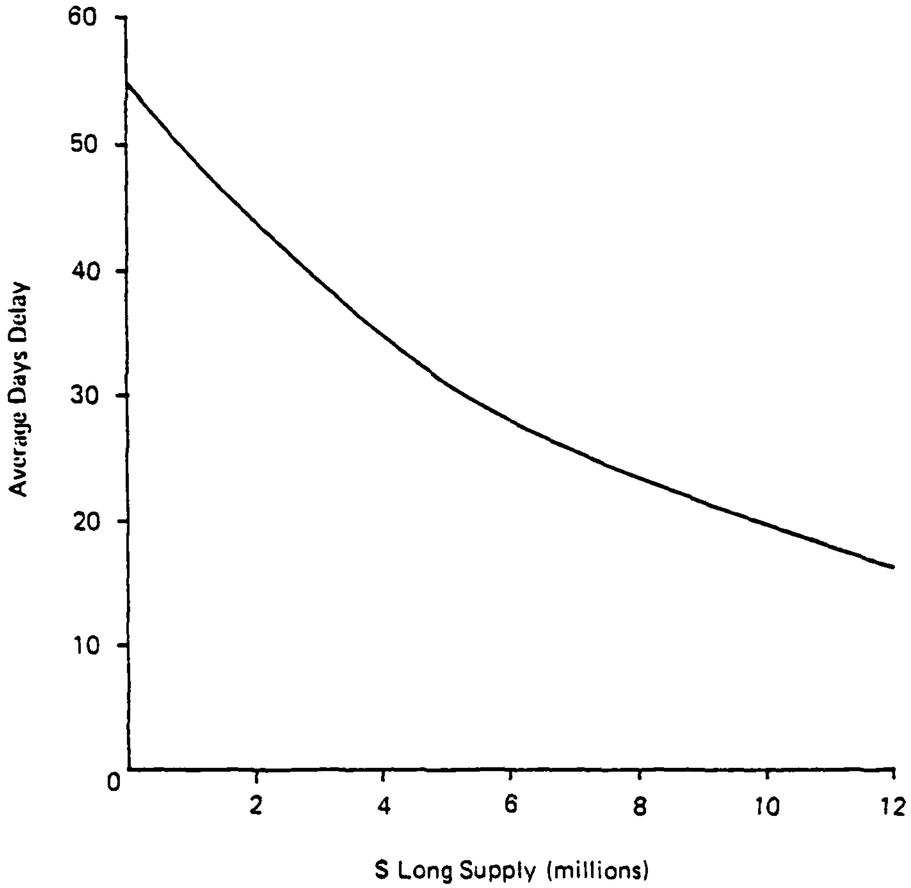
Navy Long Supply Simulation
Aviation Supply Office Sample

MARGINAL ANALYSIS OF KEY MEASURES

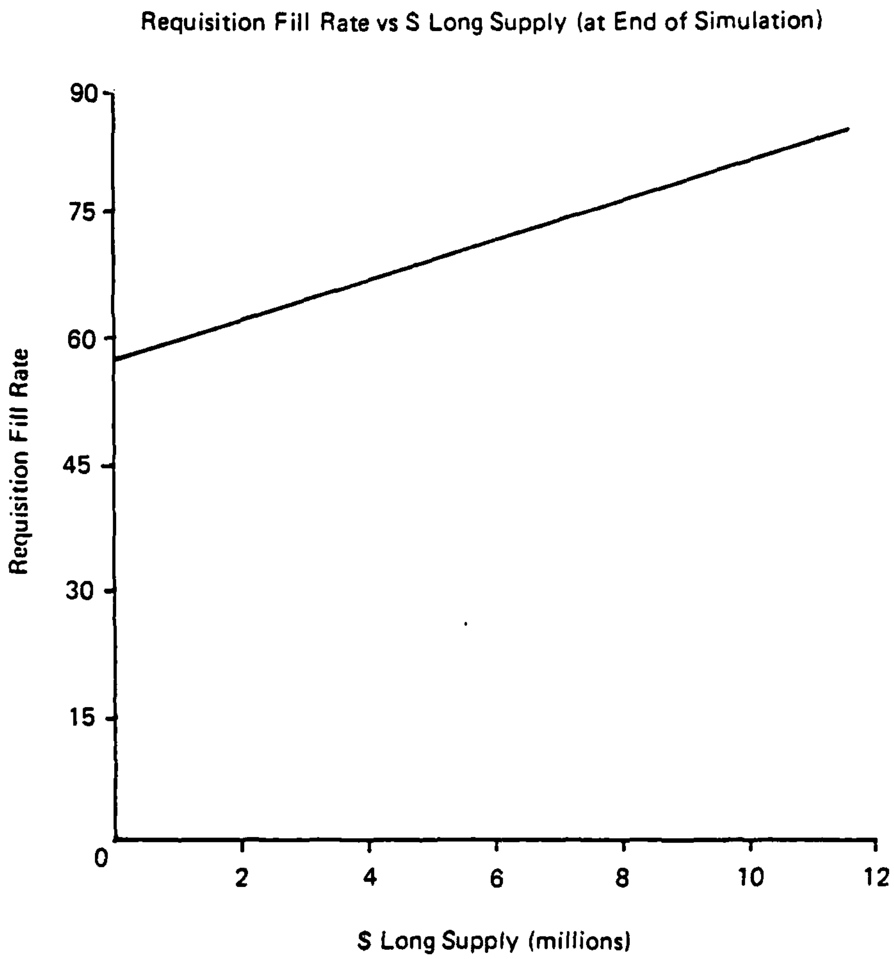
(At End of Simulation)

Change In Shortage Cost	Change In $ Long Supply	Change In $ Procurements	% Change In Requisition Fill Rate	% Change In Average Days Delay
$0 to $0.50	$ 0.7M	$ 6.0M	7.7	16.2 (8.9 Days)
$0.50 to $5	$ 3.3M	$21.9M	15.8	32.2 (14.8 Days)
$5 to $ 50	$ 3.5M	$29.7M	8.4	25.7 (8.0 Days)
$50 to $10,000	$ 3.2M	$11.6M	10.1	26.8 (6.2 Days)

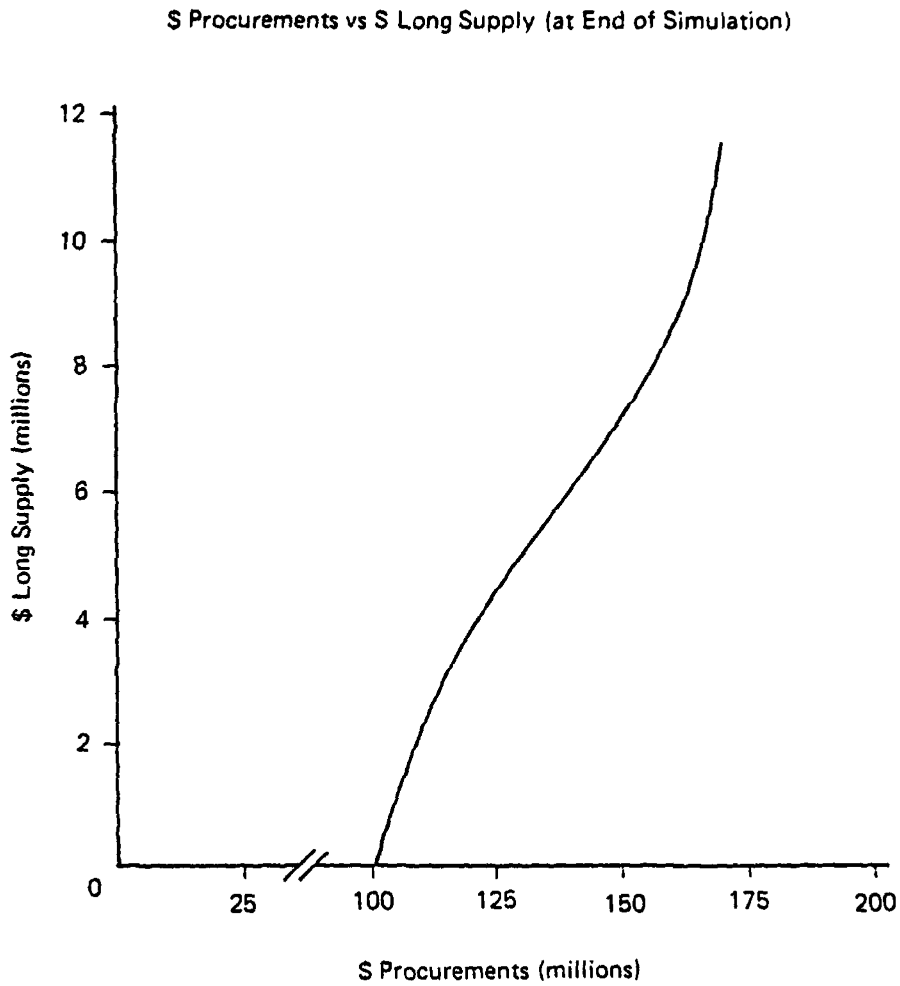
Average Days Delay vs S Long Supply (at End of Simulation)



Appendix A, Graph 1
Navy Long Supply Simulation
Aviation Supply Office Sample



Appendix A, Graph 2
Navy Long Supply Simulation
Aviation Supply Office Sample



Appendix A, Graph 3
Navy Long Supply Simulation
Aviation Supply Office Sample

APPENDIX B

TABLE 1

Navy Long Supply Simulation
Ships Parts Control Center Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.50	5.00	50.00	Maximum
SIMULATION + 6 MONTHS					
REQUISITION FILL RATE	65.1	60.7	68.5	73.6	82.1
AVERAGE DAYS DELAY	37.6	62.4	51.3	36.3	18.8
$ PROCUREMENTS (BUYS)	21.0	19.0	24.3	29.9	33.3
$ LONG SUPPLY (LS)	0.04	0.03	0.06	0.13	0.17
$ LS ÷ $ BUYS	0.002	0.002	0.003	0.004	0.005
$ SAFETY LEVEL	0	-0.85	4.5	9.7	11.9
$ ON HAND + ON ORDER	12.4	12.1	16.2	21.4	23.1
SIMULATION + 12 MONTHS					
REQUISITION FILL RATE	65.2	63.0	71.0	75.4	81.1
AVERAGE DAYS DELAY	49.2	66.4	54.0	41.4	27.7
$ PROCUREMENT (BUYS)	25.2	23.4	29.0	34.7	37.9
$ LONG SUPPLY (LS)	0.04	0.04	0.09	0.28	0.47
$ LS ÷ $ BUYS	0.001	0.002	0.003	0.008	0.012
$ SAFETY LEVEL	0	-0.53	5.1	9.9	11.8
$ ON HAND + ON ORDER	13.2	12.6	16.7	21.4	24.1
SIMULATION + 18 MONTHS					
REQUISITION FILL RATE	65.5	64.9	73.4	76.4	80.9
AVERAGE DAYS DELAY	52.5	65.9	49.4	39.2	28.5
$ PROCUREMENT (BUYS)	29.1	27.7	33.5	39.3	42.1
$ LONG SUPPLY (LS)	0.04	0.07	0.17	0.50	0.82
$ LS ÷ $ BUYS	0.002	0.002	0.005	0.013	0.020
$ SAFETY LEVEL	0	-0.17	5.5	10.2	11.8
$ ON HAND + ON ORDER	13.0	12.8	17.0	21.8	24.1
SIMULATION + 24 MONTHS					
REQUISITION FILL RATE	65.3	65.8	74.2	77.5	81.2
AVERAGE DAYS DELAY	55.8	62.8	46.7	37.5	29.1
$ PROCUREMENT (BUYS)	32.3	31.2	37.0	42.7	45.4
$ LONG SUPPLY (LS)	0.07	0.09	0.25	0.76	1.20
$ LS ÷ $ BUYS	0.002	0.003	0.007	0.018	0.026
$ SAFETY LEVEL	0	0.07	5.8	10.2	11.6
$ ON HAND + ON ORDER	12.0	12.2	16.5	21.1	23.1
SIMULATION + 30 MONTHS					
REQUISITION FILL RATE	64.9	66.7	74.9	78.6	81.6
AVERAGE DAYS DELAY	55.8	60.2	42.7	33.7	27.4
$ PROCUREMENT (BUYS)	36.9	35.8	42.0	47.8	50.6
$ LONG SUPPLY (LS)	0.14	0.14	0.38	1.1	1.6
$ LS ÷ $ BUYS	0.004	0.004	0.009	0.023	0.032
$ SAFETY LEVEL	0	0.23	6.0	10.4	12.0
$ ON HAND + ON ORDER	12.7	12.9	16.9	21.9	24.6

TABLE 1

Navy Long Supply Simulation
Ships Parts Control Center Sample

(Dollar Values In Millions)

SHORTAGE COST	SL=0	0.50	5.00	50.00	Maximum
SIMULATION + 36 MONTHS					
REQUISITION FILL RATE	64.6	66.8	74.9	78.6	81.3
AVERAGE DAYS DELAY	55.6	58.0	40.6	32.0	26.2
$ PROCUREMENTS (BUYS)	40.5	39.6	46.0	51.9	54.5
$ LONG SUPPLY (LS)	0.25	0.18	0.52	1.3	2.1
$ LS ÷ $ BUYS	0.006	0.004	0.011	0.025	0.039
$ SAFETY LEVEL	0	0.49	6.1	10.3	11.6
$ ON HAND + ON ORDER	12.5	12.3	17.4	22.5	24.7
SIMULATION + 42 MONTHS					
REQUISITION FILL RATE	64.0	67.1	74.9	78.7	81.4
AVERAGE DAYS DELAY	55.4	56.8	39.5	31.1	25.4
$ PROCUREMENT (BUYS)	43.7	43.0	49.5	55.3	58.0
$ LONG SUPPLY (LS)	0.42	0.23	0.68	1.6	2.5
$ LS ÷ $ BUYS	0.010	0.005	0.014	0.029	0.043
$ SAFETY LEVEL	0	0.69	6.3	10.4	11.8
$ ON HAND + ON ORDER	11.8	12.4	17.2	22.3	24.7
SIMULATION + 48 MONTHS					
REQUISITION FILL RATE	63.4	67.2	74.7	78.9	81.4
AVERAGE DAYS DELAY	57.6	57.0	39.1	30.3	25.2
$ PROCUREMENT (BUYS)	47.1	46.6	53.2	58.9	61.5
$ LONG SUPPLY (LS)	0.56	0.34	0.90	1.9	2.8
$ LS ÷ $ BUYS	0.011	0.007	0.016	0.032	0.045
$ SAFETY LEVEL	0	0.64	6.4	10.7	11.8
$ ON HAND + ON ORDER	11.7	12.1	17.2	22.3	24.4
SIMULATION + 54 MONTHS					
REQUISITION FILL RATE	62.9	67.2	74.6	78.9	81.4
AVERAGE DAYS DELAY	59.4	57.6	40.8	30.8	25.5
$ PROCUREMENT (BUYS)	50.5	50.0	56.7	62.7	65.4
$ LONG SUPPLY (LS)	0.68	0.43	1.1	2.2	3.3
$ LS ÷ $ BUYS	0.013	0.009	0.020	0.035	0.050
$ SAFETY LEVEL	0	0.65	6.4	10.6	11.7
$ ON HAND + ON ORDER	11.8	12.4	17.4	22.8	25.2
SIMULATION + 60 MONTHS					
REQUISITION FILL RATE	62.6	67.2	74.8	79.2	81.5
AVERAGE DAYS DELAY	61.1	57.5	41.3	30.6	25.9
$ PROCUREMENT (BUYS)	53.4	53.1	60.0	66.1	68.6
$ LONG SUPPLY (LS)	0.91	0.70	1.3	2.6	3.7
$ LS ÷ $ BUYS	0.017	0.013	0.022	0.039	0.054
$ SAFETY LEVEL	0	0.57	6.4	10.5	11.6
$ ON HAND + ON ORDER	11.8	12.5	17.5	23.0	25.1

Navy Long Supply Simulation
Ships Parts Control Center Sample

TABLE 2

REQUISITION FILL RATE

SHORTAGE COST SETTINGS	SL=0	0.50	5.00	50.00	Maximum
START OF SIMULATION PLUS:					
6 Months	65.1	60.7	68.5	73.6	82.1
12 Months	65.2	63.0	71.0	75.4	81.1
18 Months	65.5	64.9	73.4	76.4	80.9
24 Months	65.3	65.8	74.2	77.5	81.2
30 Months	64.9	66.7	74.9	78.6	81.6
36 Months	64.6	66.8	74.9	78.6	81.3
42 Months	64.0	67.1	74.9	78.7	81.4
48 Months	63.4	67.2	74.7	78.9	81.4
54 Months	62.9	67.2	74.6	78.9	81.4
60 Months	62.6	67.2	74.8	79.2	81.5

TABLE 3

AVERAGE DAYS DELAY

START OF SIMULATION PLUS:					
6 Months	37.6	62.4	51.3	36.3	18.8
12 Months	49.2	66.4	54.0	41.4	27.7
18 Months	52.5	65.9	49.4	39.2	28.5
24 Months	55.8	62.8	46.7	37.5	29.1
30 Months	55.8	60.2	42.7	33.7	27.4
36 Months	55.6	58.0	40.6	32.0	26.2
42 Months	55.4	56.8	39.5	31.1	25.4
48 Months	57.6	57.0	39.1	30.3	25.2
54 Months	59.4	57.6	40.8	30.8	25.5
60 Months	61.1	57.5	41.3	30.6	25.9

APPENDIX B

Navy Long Supply Simulation
Ships Parts Control Center Sample

TABLE 4

DOLLAR VALUE OF PROCUREMENTS ($M)

SHORTAGE COST SETTINGS	SL=0	0.50	5.00	50.00	Maximum
START OF SIMULATION PLUS:					
6 Months	21.0	19.0	24.3	29.9	33.3
12 Months	25.2	23.4	29.0	34.7	37.9
18 Months	29.1	27.7	33.5	39.3	42.1
24 Months	32.3	31.2	37.0	42.7	45.4
30 Months	36.9	35.8	42.0	47.8	50.6
36 Months	40.5	39.6	46.0	51.9	54.5
42 Months	43.7	43.0	49.5	55.3	58.0
48 Months	47.1	46.6	53.2	58.9	61.5
54 Months	50.5	50.0	56.7	62.7	65.4
60 Months	53.4	53.1	60.0	66.1	68.6

TABLE 5

DOLLAR VALUE OF LONG SUPPLY ($M)

START OF SIMULATION PLUS:					
6 Months	0.04	0.03	0.06	0.13	0.17
12 Months	0.04	0.04	0.09	0.28	0.47
18 Months	0.04	0.07	0.17	0.50	0.82
24 Months	0.07	0.09	0.25	0.76	1.20
30 Months	0.14	0.14	0.38	1.10	1.60
36 Months	0.25	0.18	0.52	1.30	2.10
42 Months	0.42	0.23	0.68	1.60	2.50
48 Months	0.56	0.34	0.90	1.90	2.80
54 Months	0.68	0.43	1.10	2.20	3.30
60 Months	0.91	0.70	1.30	2.60	3.70

Navy Long Supply Simulation
Ships Parts Control Center Sample

TABLE 6

RATIO OF $ LONG SUPPLY ÷ $ PROCUREMENTS

SHORTAGE COST SETTINGS	SL=0	0.50	5.00	50.00	Maximum
START OF SIMULATION PLUS:					
6 Months	0.002	0.002	0.003	0.004	0.005
12 Months	0.001	0.002	0.003	0.008	0.012
18 Months	0.002	0.002	0.005	0.013	0.020
24 Months	0.002	0.003	0.007	0.018	0.026
30 Months	0.004	0.004	0.009	0.023	0.032
36 Months	0.006	0.004	0.011	0.025	0.039
42 Months	0.010	0.005	0.014	0.029	0.043
48 Months	0.011	0.007	0.016	0.032	0.045
54 Months	0.013	0.009	0.020	0.035	0.050
60 Months	0.017	0.013	0.022	0.039	0.054

TABLE 7

DOLLAR VALUE OF SAFETY LEVEL

START OF SIMULATION PLUS:					
6 Months	0	-0.85	4.5	9.7	11.9
12 Months	0	-0.53	5.1	9.9	11.8
18 Months	0	-0.17	5.5	10.2	11.8
24 Months	0	0.07	5.8	10.2	11.6
30 Months	0	0.23	6.0	10.4	12.0
36 Months	0	0.49	6.1	10.3	11.6
42 Months	0	0.69	6.3	10.4	11.8
48 Months	0	0.64	6.4	10.7	11.8
54 Months	0	0.65	6.4	10.6	11.7
60 Months	0	0.57	6.4	10.5	11.6

Navy Long Supply Simulation
Ships Parts Control Center Sample

TABLE 8

DOLLAR VALUE OF ON-HAND & ON-ORDER ASSETS

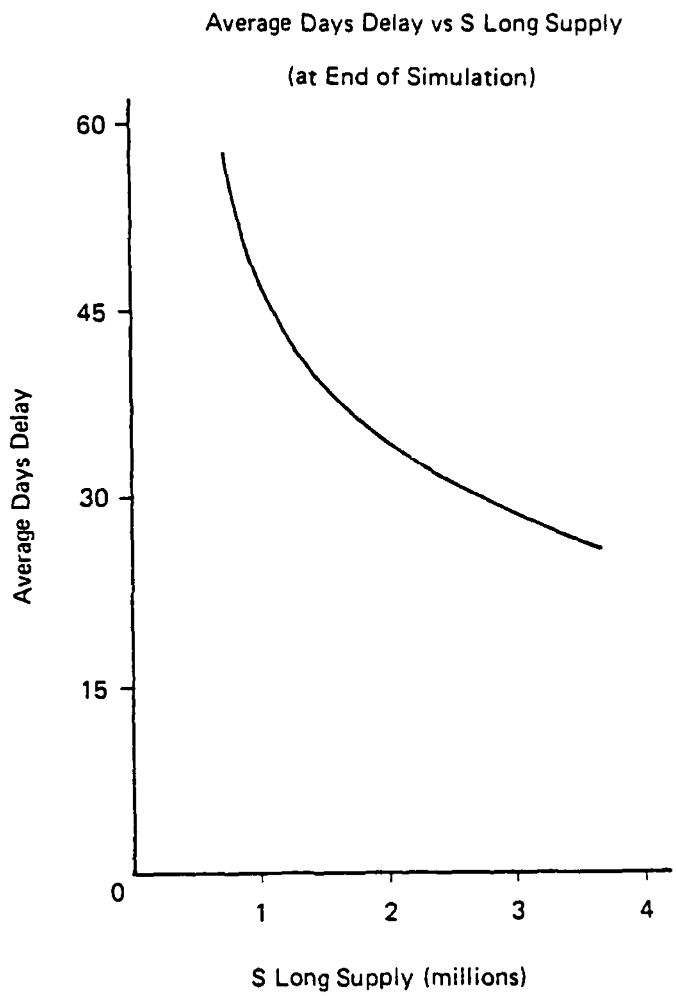
SHORTAGE COST SETTINGS START OF SIMULATION PLUS:	SL=0	0.50	5.00	50.00	Maximum
6 Months	12.4	12.1	16.2	21.4	23.1
12 Months	13.2	12.6	16.7	21.4	24.1
18 Months	13.0	12.8	17.0	21.8	24.1
24 Months	12.0	12.2	16.5	21.1	23.1
30 Months	12.7	12.9	16.9	21.9	24.6
36 Months	12.5	12.3	17.4	22.5	24.7
42 Months	11.8	12.4	17.2	22.3	24.7
48 Months	11.7	12.1	17.2	22.3	24.4
54 Months	11.8	12.4	17.4	22.8	25.2
60 Months	11.8	12.51	17.5	23.0	25.1

TABLE 9

MARGINAL ANALYSIS OF KEY MEASURES

(At End of Simulation)

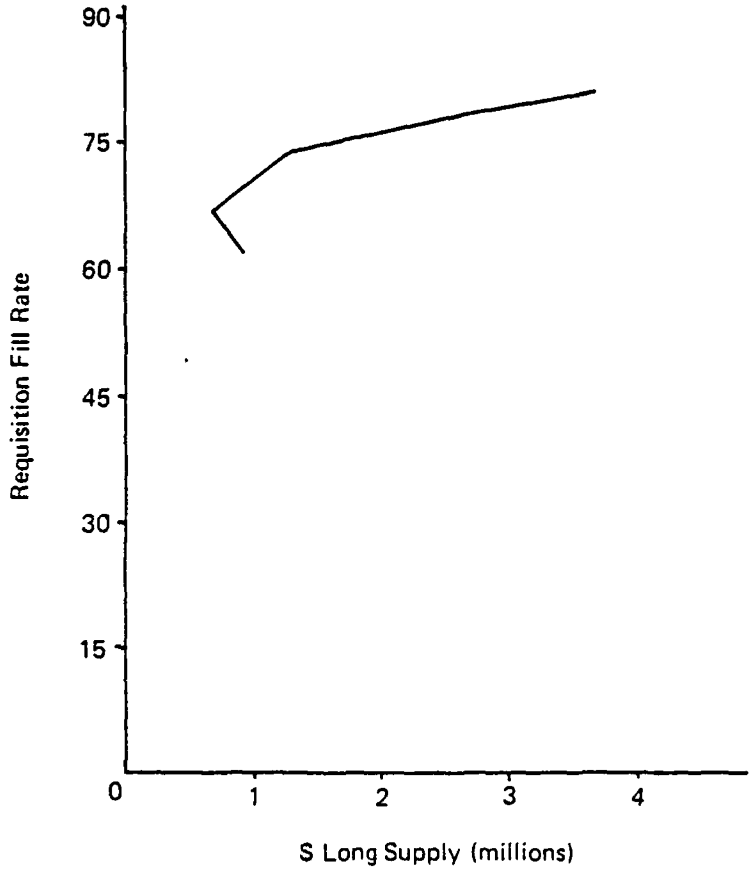
Change In Shortage Cost	Change In $ Long Supply	Change In $ Procurements	% Change In Requisition Fill Rate	% Change In Average Days Delay
$0 to $0.50	$-0.21M	$-0.3M	7.35	5.89 (3.6 Days)
$0.50 to $5	$ 0.60M	$ 6.9M	11.31	28.17 (16.2 Days)
$5 to $ 50	$ 1.3M	$ 6.1M	5.88	25.91 (10.7 Days)
$50 to $10,000	$ 1.1M	$ 2.5M	2.90	15.36 (4.7 Days)



Appendix B, Graph 1
Navy Long Supply Simulation
Ships Parts Control Center Sample

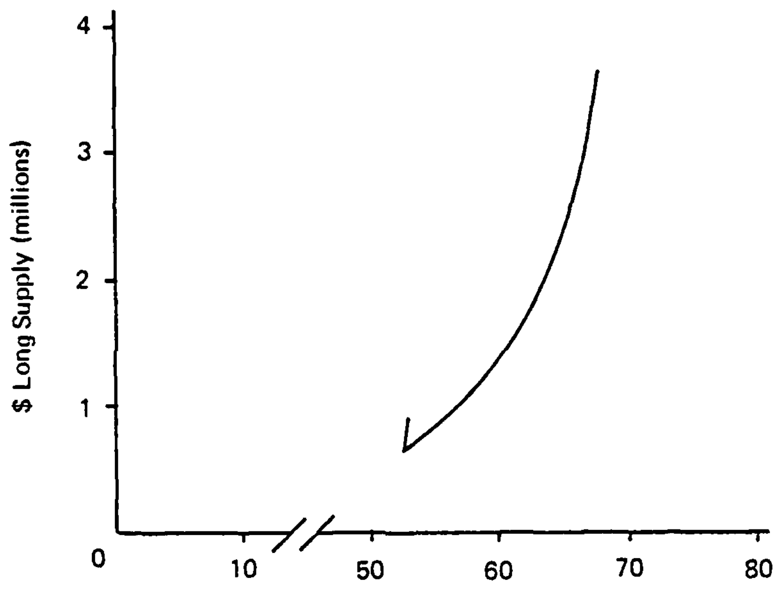
Requisition Fill Rate vs S Long Supply

(at End of Simulation)



Appendix B, Graph 2
Navy Long Supply Simulation
Ships Parts Control Center Sample

S Procurements vs S Long Supply (at End of Simulation)



Appendix B, Graph 3
Navy Long Supply Simulation
Navy Ships Parts Control Center Sample

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